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The Branner Geological Library

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TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME FIFTEENTH,

PARTS I.—XVIII.

MANCHESTER:

SOLD AT THE ROOMS OF THE SOCIETY,

36, GEORGE STREET, MANCHESTER.

1880.

212961

*** The writers of papers alone are responsible for the facts and opinions contained in their respective communications.

LIBRARY

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MANCHESTER GEOLOGICAL SOCIETY.

Established 15th October, 1838.

OBJECTS.

The objects of the MANCHESTER GEOLOGICAL SOCIETY *are the collection and diffusion of Practical and Theoretical Knowledge respecting Geology and Mining. In furtherance of such objects, original Papers on Geological and Mining subjects—either written by the members of the Society, or communicated to the Society through a member, on behalf of the authors—shall be read and discussed at its meetings, and if judged to be of sufficient interest, shall be printed at the expense of the Society, in its Transactions.*

RULES.

I.—The Society consists of Ordinary, Life, Honorary, and Corresponding Members.

II.—Every candidate for admission into the Society as an ordinary member, must be proposed by two or more members, who must sign a certificate in recommendation of him, setting forth the name, description, and place of residence of the candidate.

III.—The certificate, when duly filled up, shall be read aloud at the next ordinary meeting of the Society; and the election of the candidate shall forthwith be decided by a majority of votes.

IV.—The Secretaries shall address to every person elected a member, a notification of such election, with a copy of the printed Rules and Bye-lays of the Society.

V.—No person elected a member shall be entitled to exercise any privilege as such, until he shall have paid his annual subscription, or the composition in lieu thereof.

VI.—The annual subscription to be paid by ordinary members shall be twenty shillings, due on each successive first day of October, and payable in advance for the current year, and shall be a debt due to and recoverable as such by the Treasurer for the time being.

VII.—Members joining the Society on or after the first day of April in any year, shall pay the sum of ten shillings as the subscription for the current year.

VIII.—An ordinary member may, at his election, or any future period, become a life member by compounding for future annual subscriptions, including that of the current year, by the payment of ten pounds. If he has already paid the subscription for the current year, or any part of it, such payment shall be allowed in part of his composition.

IX.—The payment by an ordinary or life member, of the subscription, or the composition in lieu thereof, shall imply the acquiescence of such member in the Rules and Regulations of the Society, and shall entitle him (so long as no subscriptions remain unpaid) to admission to the meetings of the Society, the use of the Library, and to one copy of each of the Transactions, and of any other publications the Society may print.

X.—Individuals distinguished for their Geological or Mining researches, for their liberality to the Society, or for their connexion with other Societies, may, on the recommendation of the Council, be elected honorary or corresponding members of this Society at any ordinary or general meeting. But such honorary or corresponding members shall have no vote in the affairs of the Society.

XI.—Any member may withdraw from the Society by signifying his wish to do so, by letter under his hand, to the Secretaries, at the apartments of the Society; provided always, that such member shall be liable for the subscription for the whole year wherein he signifies his wish to withdraw; and shall continue liable to future annual subscriptions until he have discharged all sums due from him to the Society, and returned all books and

other property, if any, in his custody, belonging to the Society; or shall have made full compensation for the same if lost or not forthcoming after two months' notice from the Secretaries.

XII.—As soon as any member has let his subscriptions full two years in arrear, the Secretary shall notify the fact to him, and require him to pay what is due within one month. In case of non-compliance with such request, the Council may determine the membership of the defaulter.

XIII.—An annual meeting of the Society shall be held in the month of October, for the purpose of electing the officers for the current year, receiving the Annual Report of the Council, together with an audited statement of the Receipts and Expenditure of the last year, and transacting the general affairs of the Society. At this meeting any member may question the Council upon any matter contained in such report and comment thereon, and on any other matters of which notice in writing had been previously given to the Council, relating to the affairs of the Society, as to him may appear proper.

XIV.—Ordinary meetings of the Society shall be held once, at least, in every month, from October to June, inclusive, at such time as the Council shall appoint. Each member shall have the power to introduce visitors to the meetings, on entering their names in a book to be kept for that purpose.

XV.—Ordinary meetings may be held in other localities than Manchester, according to the pleasure of the Society, to be determined at a previous meeting.

XVI.—Circulars announcing meetings of the Society, or of the Council, shall be sent, free of postage, to the respective members of those bodies, at least three days before such meeting.

XVII.—Special general meetings may be summoned by the Council, or by the Secretaries, on the requisition in writing, of any six members of the Society, by notice delivered free, or sent by post, pre-paid, to all the members whose addresses are known, not less than one week, nor more than a fortnight, before any such

meetings. Such notice shall state the time and place of holding the meeting, and the specific purposes for which it is convened; and the business of such meeting shall be restricted to such purposes.

XVIII.—At the hour appointed for a meeting of the Society or Council, the chair shall be taken by the President, or the senior Vice-President present, and in their absence the meeting shall, previously to entering upon any other business, elect some member present to be Chairman.

XIX.—All questions discussed at any such meeting, except as otherwise provided, shall be decided by a majority of votes; and if upon any question the votes shall be equal, the Chairman of the meeting shall have a second vote as a casting vote.

XX.—No business shall be done at any such ordinary or special meeting unless when five members at least are present, except that any number of member who may be present, not being less than two, may adjourn the meeting to a future day, such adjourned meeting to be summoned in the same manner as the original meeting.

XXI.—A President, four Vice-Presidents, two Honorary Secretaries, and a Treasurer, shall be elected at each annual meeting; and the foregoing, together with twelve ordinary members to be elected at the same time, shall form the Council of the Society, and shall have the management of its affairs, except as otherwise provided by these Rules; and at the same meeting two Auditors shall be elected for the year ensuing. These elections shall be by ballot. In addition to the four Vice-Presidents annually elected, the Ex-Presidents shall be *ex post facto* Vice-Presidents of the Society.

XXII. Any member who has been for six months a member of the Society, and whose subscription is not in arrear, shall be eligible to be elected an officer or member of the Council.

XXIII.—In the event of any vacancy occurring during the year in the offices or Council, the same shall be filled up by the Council.

XXIV.—The President shall not be eligible for that office for more than two years in succession; and the two Vice-Presidents, and the four members of the Council who shall have attended the meetings of Council the least number of times, shall be ineligible to the same office for the ensuing year.

XXV.—The Council shall have power to make Bye-laws and Regulations, in accordance with the general Rules of the Society, to appoint, suspend, or dismiss salaried agents, clerks, or servants; to purchase and collect books, maps, models, specimens, and other objects; to provide rooms for the meetings of the Society, and pay rent for the same; and to purchase furniture or other articles that they deem necessary for the use of the Society.

XXIV.—The Council shall meet once at least in every month, and upon such other occasions as they may deem expedient. Special meetings of the Council may be called by either of the Secretaries, or on the requisition of any three members of the Council, of which number the officer convening such meeting may be one; any three members of the Council present at a meeting being sufficient to constitute a quorum.

XXVII.—A minute of the proceedings of all meetings shall be entered by the Secretaries in a book to be kept for that purpose.

XXVIII.—The Council shall decide whether a paper shall be printed in the Transactions or not, and if they do not unanimously agree to print it, or reject it, they may refer it to one or more members of the Society, to report upon its merits, and, in exceptional cases, refer it to competent persons who are not members. After having received such reports, the Council shall decide without delay whether or not the paper is to be printed. The author of a paper shall be at liberty to reserve his right of property therein, and shall have a right to withdraw it from publication, by giving timely notice to the Council.

XXIX.—All moneys, the Library, and all chattels of the Society, shall be held by the President and Treasurer for the time being, as legal owners thereof, but in trust for the Society, and under the

direction of the Council, and all investments shall be made in the names of such members, not being less than two, as the Society may from time to time appoint.

XXX.—All the funds and moneys of the Society shall be applied by or under the direction of the Council, in paying the debts and demands for the time being owing by the Society, and carrying out the purposes thereof as defined in the preceding Rules; and no dividend, gift, division, or bonus in money shall at any time, or under any circumstances, be made unto or between the members of the Society or any of them.

XXXI.—No additional rule, nor any alteration or repeal of any existing or future rule or rules of the Society shall be made, unless with the consent of three-fourths in number of such of the ordinary and life members as may be present at any annual or special meeting; and the proposed change must be announced by circular to the members whose addresses are known, at least three weeks before such meeting.

XXXII.—The Society shall not be dissolved, nor shall the Library or other property be disposed of, unless with the consent, in writing, of three-fourths of such of the ordinary and life members as may be present at each of two successive special general meetings, duly convened by public advertisement in the Manchester daily newspapers, and by notice sent by post at least one calendar month before each meeting, to all members, whose addresses are known; such meetings to be held at an interval of not less than two, nor more than four, calendar months.

BYE-LAWS

FOR

REGULATION OF THE LIBRARY.

I.—No Book, Map, or document shall be taken from the Library without the same being first entered in a Register, in such manner as the Council shall from time to time direct.

II.—The time allowed for retaining a Book, &c., shall not exceed one calendar month.

III.—No Member shall be allowed to renew a Volume, Map, &c., in case any other Member shall have entered his name as being desirous of taking out the same on its return. Such Volume, Map, &c., shall, on its return from the person holding the same, be entered as taken out by the Member so applying, and shall not be taken away by any Member, save him in whose name it is entered, till the expiration of the period for which the Member in whose name it is entered would have been entitled to hold the same. At which period the said Book, &c., (in case the same shall not have been taken out by the party in whose name it is entered on the Register,) shall be marked in the Register as returned.

IV.—The time allowed for holding shall, in every case, be computed from the date of the entry in the Register.

V.—Every Member shall return the Books, Maps, and documents belonging to the Society in as good a condition as when they were delivered into his possession, and shall be answerable for the same till their return from him, to the Society, is correctly entered in the Register.

By order of the Council,

JOHN EDWARD FORBES, F.G.S., } HONORARY
JOHN PLANT, F.G.S., } SECRETARIES.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XV. SESSION 1878-9.

ANNUAL MEETING.

The ANNUAL MEETING of the Members of the Society was held on Tuesday, the 29th October, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., President,
in the Chair.

Mr. James Ashworth, 56, Upper Duke Street, Southport; Mr. Abel Clayton, Mining Engineer, 11, Chapel Walks, Manchester; Mr. Simon Nall, Land and Mine Surveyor, Newbold, Rochdale; Mr. William Nelson, Colliery Manager, Leigh, Lancashire; Dr. J. Beswick Perrin, The Homestead, Leigh, Lancashire; and Mr. James Henry Stephens, Land and Mine Surveyor, Leigh, Lancashire, were elected ordinary members of the Society.

The Report of the Council and the Treasurer's Balance Sheet, were read by Mr. J. S. Martin, Honorary Secretary.

REPORT OF THE COUNCIL FOR 1877-8.

Your Council have pleasure in being able to report that the Session of 1877-8 has been a prosperous one. The number of members has been increased. Interesting and

important papers have been read, and important subjects brought before the meetings, and the discussions thereon well maintained. The average attendance of members has also been satisfactory, showing an increased interest in the Society and the subjects brought forward.

Seventeen new members have been elected, viz.:—1 honorary and 16 ordinary members, while the loss has been 8, viz.: 1 honorary and 2 ordinary members deceased, and 5 ordinary members resigned. The number now enrolled is 153, viz.: 10 life members, 17 honorary members, and 126 ordinary members.

Nine meetings have been held, and the parts of the transactions appertaining thereto have been distributed among the members and the societies with which publications are exchanged.

The funds of the Society are in a satisfactory state, the sum of £600 remains invested in the 4 per cent. Guaranteed Stock of the Birkenhead Railway. The outstanding subscriptions, as well as the liabilities, are small in amount, as will be seen by reference to the Balance Sheet.

The Library has been increased by the addition of many valuable works, including the Transactions and Publications of many kindred societies in Great Britain and abroad; but in consequence of the very limited space available in the present rooms, it is impossible that they can all be available for the use of the members. Your Council regret having been so far unsuccesful in overcoming this difficulty, but endeavours are being made to provide increased conveniences.

It is with considerable pleasure that your Council is able to announce that the authorities of The Owens College have opened the Geological Museum in accordance with the Articles of Agreement, by which they became possessed of this Society's collection, and respecting which, they were in correspondence at this time last year.

The advantages thus obtained will be best seen by inserting the following extract from the "*Calendar* of The Owens College" for the Session 1878-9:—

"THE MANCHESTER MUSEUM, OWENS COLLEGE.

"*Curator*, W. Boyd Dawkins, M.A., F.R.S., F.G.S., F.S.A.

"The Museum contains, in addition to a small typical Collection previously the property of the College, the entire Collections of the Manchester Natural History Society and of the Manchester Geological Society, which those Societies transferred to the College on its removal to the new buildings in Oxford Road; and also the complete Mineralogical and Metallurgical Collections of the late David Forbes, Esq., F.R.S., arranged and classified by him. The Natural History Collections are temporarily arranged, together with the College Collection, in the upper story of the new building in Oxford Road.

"The Zoological series is arranged for the use of students according to Professor Huxley's classification. There is a small Osteological collection, and the most important zoological points are noted for the use of students in a M.S. book kept in the Museum.

"The Geological collections are fully arranged, the *characteristic* fossils being distinguished by mounts or labels of a red colour. The rock specimens and groups of volcanic products and minerals are placed in illustration of the most important books in each line of inquiry.

"Students of the College are admitted to the Museum on any day during College hours, on presenting a card which they can obtain from a Professor or Lecturer, and on signing their names each time in the Attendance Book.

"Text-books for each subject are kept in the Museum for reference, and the students will be assisted in their study of the specimens.

"The Geological collections are open to the Public *free* on Tuesdays, Thursdays, and Saturdays, from 10 a.m. to 4 p.m., and on Saturday evenings from 6-30 to 9 p.m. They are further open to students on Wednesdays and Fridays, from 10 a.m. to 4 p.m., and on Friday evenings, from 6-30 to 9 p.m.

"The Museum is closed during the month of August, and from the 23rd December to the 2nd January inclusive. Admission free and without ticket.

"Students and Visitors will be required to sign their names in a book on each visit, except in special cases to be determined by the Curator.

"The persons who were lately Governors of the Manchester Natural History Society, and the members of the Manchester Geological Society for the time being, have free access to the Museum for themselves and their friends on each week day (Friday excepted).

"The admission of the Public to the Zoological Museum is necessarily suspended until adequate accommodation is provided."

In accordance with a motion put and carried at one of the concluding meetings of the preceding session, the Hon. Secretaries issued a circular to the members requesting them to state the day and hour which would be most convenient for the holding of the Society's meetings, the result being a large majority, of those who replied, in favour of the present arrangement.

It is with feelings of sorrow that your Council have to announce the loss by death, during the Session, of the following esteemed and well-known members: Mr. Thomas Livesey, who since the foundation of the Society has been connected with it, as well as a frequent attendant at the meetings, and Mr. John Cross, of Wigan,—Ordinary Members, and Mr. John Thomas Woodhouse, F.G.S., M.Inst.C.E., Honorary Member.

Dr. MANCHESTER GEOLOGICAL SOCIETY, BALANCE SHEET. Cr.

Abstract of Receipts.

1877-8.	£	s.	d.
To Bank Interest	0	5	2
,, Birkenhead Dividends	23	13	0
,, Sale of Transactions	1	2	0
,, Subscriptions and Arrears	127	10	0
,, Balance due to Treasurer	27	17	1
	£180	7	3

The Investments consist of £600 Four per cent. Guaranteed Stock of the Birkenhead Railway, in the names of Henry Mere Ormerod and Andrew Knowles.

Abstract of Payments.

1877-8.	£	s.	d.
By Balance due to Treasurer	11	17	0
,, Library	13	15	6
,, Reporters	9	9	0
,, Transactions, Reports, &c.	86	15	0
,, Postages, &c.	20	14	3
,, Collector's Commission	6	7	6
,, Rent	30	0	0
,, Insurance	0	18	6
,, Law Charges	0	10	6
	£180	7	3
October, 1878.			
,, Balance brought down	£27	17	1

HENRY M. ORMEROD, Treasurer.

26th October, 1878.

Audited and found correct,

CLEGG LIVESEY, Auditor.

THE FOLLOWING PAPERS AND COMMUNICATIONS HAVE BEEN BROUGHT BEFORE THE ORDINARY MEETINGS DURING THE SESSION.

1877.

October. Dawkins, W. Boyd, F.R.S., "On the Antiquity of Man."

November. Kinahan, G. H., M.R.I.A., "On Quartzyte (Quartz-Schist), Quartz-Rock (Gressen)."

December. Dickinson, Joseph, F.G.S., (President), "On the Davy Lamp and Blasting in Mines."

Johnson, W. H., "On the Resources and Future Development of the Coal Fields of Europe."

1878.

January. Pebbles from the Coal.

Hull, Edward, F.R.S., "On the Occurrence of Brine in the New Red Sandstone Strata at Warrington."

Demmler, A., "On Boring Shafts, &c., in Westphalia."

February. Evans, T. F., "On the Mines of the Parys Mountain, Anglesea."

March. The Spontaneous Combustion of Coal.

Discussion on Mr. Evans's Paper "On the Parys Mountain Mines."

De Rance, C. E., F.G.S., "On the Palæozoic and Secondary Rocks of England, as a source of Water Supply for Towns and Districts."

April. Discussion on Mr. De Rance's Paper, read at the previous Meeting.

Grimshaw, W. J., F.G.S., "On Sinking of Surface, owing to Working of Coal Mines."

May. Waters, A. W., F.G.S., "Remarks on some Fenestellidae."

Waters, A. W., F.G.S., "On Bryozoa (Polyzoa) from the Pliocene of Bruccoli (Sicily).

Sutherland, Alexander, "On Lighting Shots in Mines."

Letter from Major Ford.

June. Letter from Mr. E. W. Binney, F.R.S.

Wild, George, "On Explosions in Mines."

The Report and Balance Sheet were unanimously adopted and ordered to be printed.

The following gentlemen were then proposed and seconded, and declared duly elected as Officers and Members of the Council for the ensuing year:—

President:

JOHN EDWARD FORBES, F.G.S.

Vice-Presidents:

THOMAS BROOKS.
R. D. DARBISHIRE, F.G.S.
RIGHT HON. THE EARL OF DERBY, K.G.
SIR U. J. KAY-SHUTTLEWORTH, BART., M.P.

Ex-Officio Vice-Presidents:

JAMES HEYWOOD, F.R.S.	G. C. GREENWELL, F.G.S.
G. W. ORMEROD, F.G.S.	JOHN AITKEN.
E. W. BINNEY, F.R.S.	JOHN KNOWLES, M.Inst.C.E.
JOSEPH DICKINSON, F.G.S.	THOMAS KNOWLES, M.P.
ANDREW KNOWLES.	W. BOYD DAWKINS, F.R.S.

R. CLIFFORD SMITH, F.G.S.

Treasurer:

HENRY MERE ORMEROD. F.G.S.

Secretaries:

JOSEPH S. MARTIN, F.G.S. | W. J. GRIMSHAW, F.G.S.

Other Members of the Council:

W. H. CHADWICK.	EDWARD PILKINGTON.
RALPH FLETCHER, Junr.	J. F. SEDDON.
G. C. GREENWELL, Junr.	W. SMETHURST, F.G.S.
JOHN HIGSON, F.G.S.	PETER SPENCE, F.G.S.
CHARLES HARDWICK.	A. W. WATERS, F.G.S.
PETER PICKUP, F.G.S.	GEORGE WILD.

Auditors:

JOHN HEELIS. | CLEGG LIVESEY.

In acknowledging a vote of thanks to him as retiring President, Mr. Dickinson said that he felt a warm interest in the Society, and that he not only considered it a pleasure to aid it, but that he was also furthering his public duty by so doing.

NEW ORDINARY MEMBERS.

Adamson, D., F.G.S.
Arthur, David.
Atherton, James.
Cooke, Charles.
Cowburn, Henry.
Evans, T. F.
Jackson, Lewis.
Livesey, Thomas, Junr.
Ogden, Samuel.
Peace, Maskell W., F.G.S.
Robins, George.
Shuttleworth, Sir U. J. Kay, Bart., M.P.
Smallshaw James.
Smith, Richard.
Wheeler, Harold George.
Wild, Joseph.

NEW HONORARY MEMBER.

C. E. De Rance, F.G.S.

MEMBERS DECEASED.

John Cross.
Thomas Livesey. } Ordinary Members.

John Thomas Woodhouse, F.G.S., Hon. Member.

MEMBERS RESIGNED.

A. A. Diggle.
R. A. Eskrigge, F.G.S.
W. H. Johnson, B.Sc.
Kay Knowles.
Joseph Thomson, F.G.S.

LIST OF MEMBERS.

NOVEMBER, 1878.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander,* Cambridge, Massachussetts, U.S.A.
1863	Aitken, John, Sandfield, Urmston. *Ex-President.*
1862	Alcock, Thomas, M.D., Oak Field, Ashton-on-Mersey.
1877	Arthur, David, Baxenden Collieries, near Accrington.
1865	Ashworth, Edward, Stagg Hills, Waterfoot, near Manchester.
1878	Ashworth, James, 56, Upper Duke Street, Southport.
1864	Ashworth, John, Rose Hill, Turton, near Bolton.
1877	Atherton, James, 16, Acresfield, Bolton.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1875	Bangay, Dr. Richard, Cheadle, Cheshire.
1876	Barnes, R. J., Birley Collieries, near Sheffield.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool.
1858	Bazley, Sir Thomas, Bart., M.P., Eyford Park, Stow-on-the-Wold, Gloucestershire.
1877	Beswick, James, Little Hulton, near Bolton.
1862	Beswicke, William, Balgay Terrace, Rochdale.
1838	Binney, E.W., F.R.S., F.G.S., 55, Peter Street, Manchester. *Ex-President.*
1867	Bolton, H. H., Newchurch, near Manchester.
1877	*Broeck, Ernest Vanden,* 124, Rue Terre Neuve, Brussells.
1877	*Brongniart, Charles,* Museum d'Histoire Naturelle, 57, Rue Cuvier, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1859	Bryham, William, Rose Bridge Colliery, Wigan.
1862	*Buccleuch, His Grace the Duke of, Whitehall Gardens, London, S.W.

Year of Election.	
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1874	Byrom, W. A., F.G.S., 31, King Street, Wigan.
1876	Chadwick, W. H., Bank Collieries, Little Hulton, Bolton.
1878	Clayton Abel, 11, Chapel Walks, Manchester.
1878	Cooke, Charles, Moston Colliery, Failsworth.
1859	*Coulthard, J. Ross, F.R.S.L., Croft House, Ashton-under-Lyne.
1878	Cowburn, Henry, West Leigh, near Manchester.
1874	Crofton, Rev. A., M.A., The Parsonage, Reddish Green, Stockport.
1862	Cross, John, 78, Cross Street, Manchester.
1860	Crowther, Samuel, Bradford Estate Offices, Bolton.
1876	Cunliffe, P. G., The Elms, Handforth, near Manchester.
1860	Darbishire, R. D., B.A., F.G.S., 26, George Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *Ex-President.*
1877	*De Rance, C.E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1862	*Derby, The Right Hon. the Earl of, Knowsley.
1877	Derry, Jos, Sneyd Colliery, Burslem.
1856	Dickinson, Joseph, F.G.S.. H.M. Inspector of Mines, South Bank, Pendleton. *Ex-President.*
1859	Diggle, James, West Leigh Collieries, Leigh.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, M.P., Worsley Hall, near Manchester.
1838	*Egerton, Sir Philip de Malpas Grey, Bart., M.P., F.R.S., Oulton Park, Tarporley. *Ex-President.*
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1838	*Enniskellen Earl of*, F.R.S., Florence Court, Fermanagh.

Year of Election.	
1878	Evans, T. F., H.M. Inspector of Mines, Amlwch, Anglesea.
1865	Evans, Walter, Longsight, Oldham.
1863	Farrer, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1857	Forbes, John Edward, F.G.S., 2, Shrubland View, Hoole, Chester. *President.*
1873	Garforth, W. E., Lord's Field Colliery, Ashton-under-Lyne.
1874	*Geikie, Archibald,* LL.D., F.R.S., Ramsay Lodge, Edinburgh.
1858	Gerard, Lord, of Bryn, Garswood, Newton-le-Willows.
1856	Gilroy, George, M. Inst. C.E., Hindley Hall, Wigan.
1877	Goodwin, George, Broomstair Colliery, Denton.
1852	Greg, Robert Phillips, F.G.S., Coles Park, Buntingford, Herts.
1863	Greenwell, G. C., F.G.S., 8, Prior Terrace, Tynemouth, *Ex-President.*
1874	Greenwell, G. C., junr., Poynton, near Stockport.
1864	Grimshaw, W. J., F.G.S., Stand, Whitefield, near Manchester. *Hon. Secretary.*
1877	Grundy, H. T., Radcliffe.
1877	Grundy, Joseph, Radcliffe.
1838	Hadfield, George, 24, Fountain Street, Manchester.
1866	Hall, John, Balderstone, Walmersley.
1864	Hall, Robert, Hope Foundry, Bury.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester.
1874	*Hawkins, B. W.,* F.G.S., Century Club, East 15th Street, New York, U.S.A.

important papers have been read, and important subjects brought before the meetings, and the discussions thereon well maintained. The average attendance of members has also been satisfactory, showing an increased interest in the Society and the subjects brought forward.

Seventeen new members have been elected, viz.:—1 honorary and 16 ordinary members, while the loss has been 8, viz.: 1 honorary and 2 ordinary members deceased, and 5 ordinary members resigned. The number now enrolled is 153, viz.: 10 life members, 17 honorary members, and 126 ordinary members.

Nine meetings have been held, and the parts of the transactions appertaining thereto have been distributed among the members and the societies with which publications are exchanged.

The funds of the Society are in a satisfactory state, the sum of £600 remains invested in the 4 per cent. Guaranteed Stock of the Birkenhead Railway. The outstanding subscriptions, as well as the liabilities, are small in amount, as will be seen by reference to the Balance Sheet.

The Library has been increased by the addition of many valuable works, including the Transactions and Publications of many kindred societies in Great Britain and abroad; but in consequence of the very limited space available in the present rooms, it is impossible that they can all be available for the use of the members. Your Council regret having been so far unsuccesful in overcoming this difficulty, but endeavours are being made to provide increased conveniences.

It is with considerable pleasure that your Council is able to announce that the authorities of The Owens College have opened the Geological Museum in accordance with the Articles of Agreement, by which they became possessed of this Society's collection, and respecting which, they were in correspondence at this time last year.

The advantages thus obtained will be best seen by inserting the following extract from the "*Calendar* of The Owens College" for the Session 1878-9:—

"THE MANCHESTER MUSEUM, OWENS COLLEGE.

"*Curator*, W. Boyd Dawkins, M.A., F.R.S., F.G.S., F.S.A.

"The Museum contains, in addition to a small typical Collection previously the property of the College, the entire Collections of the Manchester Natural History Society and of the Manchester Geological Society, which those Societies transferred to the College on its removal to the new buildings in Oxford Road; and also the complete Mineralogical and Metallurgical Collections of the late David Forbes, Esq., F.R.S., arranged and classified by him. The Natural History Collections are temporarily arranged, together with the College Collection, in the upper story of the new building in Oxford Road.

"The Zoological series is arranged for the use of students according to Professor Huxley's classification. There is a small Osteological collection, and the most important zoological points are noted for the use of students in a M.S. book kept in the Museum.

"The Geological collections are fully arranged, the *characteristic* fossils being distinguished by mounts or labels of a red colour. The rock specimens and groups of volcanic products and minerals are placed in illustration of the most important books in each line of inquiry.

"Students of the College are admitted to the Museum on any day during College hours, on presenting a card which they can obtain from a Professor or Lecturer, and on signing their names each time in the Attendance Book.

"Text-books for each subject are kept in the Museum for reference, and the students will be assisted in their study of the specimens.

"The Geological collections are open to the Public *free* on Tuesdays, Thursdays, and Saturdays, from 10 a.m. to 4 p.m., and on Saturday evenings from 6-30 to 9 p.m. They are further open to students on Wednesdays and Fridays, from 10 a.m. to 4 p.m., and on Friday evenings, from 6-30 to 9 p.m.

"The Museum is closed during the month of August, and from the 23rd December to the 2nd January inclusive. Admission free and without ticket.

"Students and Visitors will be required to sign their names in a book on each visit, except in special cases to be determined by the Curator.

"The persons who were lately Governors of the Manchester Natural History Society, and the members of the Manchester Geological Society for the time being, have free access to the Museum for themselves and their friends on each week day (Friday excepted).

"The admission of the Public to the Zoological Museum is necessarily suspended until adequate accommodation is provided."

In accordance with a motion put and carried at one of the concluding meetings of the preceding session, the Hon. Secretaries issued a circular to the members requesting them to state the day and hour which would be most convenient for the holding of the Society's meetings, the result being a large majority, of those who replied, in favour of the present arrangement.

It is with feelings of sorrow that your Council have to announce the loss by death, during the Session, of the following esteemed and well-known members: Mr. Thomas Livesey, who since the foundation of the Society has been connected with it, as well as a frequent attendant at the meetings, and Mr. John Cross, of Wigan,—Ordinary Members, and Mr. John Thomas Woodhouse, F.G.S., M.Inst.C.E., Honorary Member.

Dr. MANCHESTER GEOLOGICAL SOCIETY, BALANCE SHEET. Cr.

ABSTRACT OF RECEIPTS.

1877-8.	£	s.	d.
To Bank Interest	0	5	2
,, Birkenhead Dividends	23	13	0
,, Sale of Transactions	1	2	0
,, Subscriptions and Arrears	127	10	0
,, Balance due to Treasurer	27	17	1
	£180	7	3

The Investments consist of £600 Four per cent. Guaranteed Stock of the Birkenhead Railway, in the names of Henry Mere Ormerod and Andrew Knowles.

ABSTRACT OF PAYMENTS.

1877-8.	£	s.	d.
By Balance due to Treasurer	11	17	0
,, Library	13	15	6
,, Reporters	9	9	0
,, Transactions, Reports, &c.	86	15	0
,, Postages, &c.	20	14	3
,, Collector's Commission	6	7	6
,, Rent	30	0	0
,, Insurance	0	18	6
,, Law Charges	0	10	6
	£180	7	3
October, 1878.			
,, Balance brought down	£27	17	1

HENRY M. ORMEROD, TREASURER.

26th October, 1878.

Audited and found correct,

CLEGG LIVESEY, AUDITOR.

Mr. SMITH said that from his experience, props ought to be set at right angles to the inclination; it was a thing he had insisted on for more than 20 years. He remembered once going to a working place and asking an aged miner why he did not do so, and after a long while he said it was on account of being easier to knock them out; and that he thought if colliers were canvassed they would generally give the same reason. He thought every practical miner must have found that a prop set at right angles would bear the greatest weight. He believed that thousands of props had been lost and scores of places brought in through props not being set at right angles to the inclination of the seam.

Mr. DICKINSON thought there was something more than drawing the props which induced colliers not to set the props at right angles to the inclination of the strata. They were so set when the men themselves did not draw the props. This fact must be borne in mind: gravity acts perpendicularly, and if in a seam dipping one in three, the prop is set at right angles to it, it is not in the best position for resisting gravity. That was one of the points which he understood was sometimes put in the examinations of colliery managers and others. He had known various answers given to the same question.

Mr. RADCLIFFE thought that if set slack in steep measures, a prop ought to be left short of its set; but to be set properly, in his opinion, a prop ought to be well rung up, and at right angles to the seam.

Mr. SEDDON agreed with the Chairman that in steep measures the greatest pressure from above was exerted in a line half way between right angles to the inclination of the strata, and vertical. He had always understood the reason for setting timber with the thick end up to be because it presented a greater bearing surface to the roof. He had heard that a solution of tungstate of soda applied to timber,

as well as brattice cloth, had a great effect in rendering it non-inflammable. He had been educated in the belief that only three sorts of timber should be used about a colliery, viz., oak, larch, and pitch pine.

Mr. R. FLETCHER, jun., said he was surprised to find on taking down a headgear lately at their collieries that the pitch pine of which it was constructed was as good and sound as when it was put up 25 years ago. It had only had one coat of paint.

Mr. DICKINSON did not consider the difficulties referred to by the writer of the paper as to dealing with large cavities in the roof insurmountable. If the timber was left naked they could throw the air up by means of sheeting; and if they had a thin material to prevent the timbering from being broken they should keep the end open, and just throw sufficient air over the top to prevent gas from accumulating.

Mr. SEDDON would be glad to hear the Chairman's views as to whether it was best to place a lot of packing upon the top of the bars, and cover it with *debris*, or leave the timbers open and drive air into the cavity by sheets, and so sweep any gas out?

Mr. DICKINSON said there were other reasons besides those stated in the paper why the timbers should be covered. For instance, in such a place as Mr. Grimshaw had described, where the roof is much fallen it would not be safe to leave the places between the couplings open because there were generally loose stones which would drop down on people passing. Therefore some stowing on the top, if even not stowed tight, was essential not only to guard against the breaking of the timber but also to prevent stones falling upon passers by. Unless the place was very high it was often best to stow it tight—stow it full,—and then there was no place where the gas could accumulate.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3	Heywood, James, F.R.S., F.G.S.
1843-4-5	Egerton, Sir Philip de Malpas Grey-, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1849-50-1	Heywood, James, M.P., F.R.S.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1855-6-7	Egerton, Sir Philip de Malpas Grey-, Bart., F.G.S.
1857-8-9	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1861-2-3	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1865-6-7	Binney, E. W., F.R.S., F.G.S.
1867-8-9	Greenwell, G. C., F.G.S.
1869-70-1	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M. Inst. C.E.
1878-4	Knowles, Thomas, M.P.
1874-5	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1876-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1877-8	Dickinson, Joseph, F.G.S.

PRESENTATIONS TO THE LIBRARY, 1877-78.

Barrow Naturalists' Field Club.—Transactions. Vol. 1, 2. 1876-8.

Belfast Natural History and Philosophical Society.—Proceedings. 1876-7. From the Society.

Bristol Naturalists Society.—Proceedings. Vol. 2. Part 1. 1877-8.

Cornwall and Devon.—Reports and Proceedings of the Miners' Association. 1871-2-3-4-5, and 7.

Cornwall.—Royal Institution Journal. No. 19. 1877.

Geological and Polytechnic Society of the West Riding of Yorkshire.—Proceedings. Part 4. 1877. From the Society.

Glasgow Geological Society.—Transactions. Vol. 5. Part 2. 1877.

Glasgow Natural History Society.—Proceedings. Vol. 3. Parts 2 and 3. 1877. From the Society.

Ireland.—Journal of the Royal Geological Society. Vol. 3. Parts 2, 3, 4. 1877-8.

Leeds Philosophical and Literary Society.—Address by the Archbishop of York, 1877. From the Council.

Leicester Literary and Philosophical Society.—Transactions. 1845 to 1850. From the Council.

Liverpool Geological Society.—Proceedings. Part 3. Vol. 3. 1877. From the Society.

London Geological Society.—Quarterly Journal. Nos. 132 to 136, and Abstracts of Proceedings for the Session 1877-8. From the Society.

London Geologists' Association.—Proceedings. Nos. 3, 4, 5, 6. Vol. 5. 1877-8. Annual Report, 1877. From the Council.

Midland Institute of Engineers.—Complete Set of Transactions to October, 1878. Parts 1-45.

Oxford University.—Supplementary Catalogue of Books on Natural Science added to the Radcliffe Library, in 1877. Per Dr. H. M. Ackland, Librarian.

Royal Institution of Great Britain.—Proceedings. Vol. VII. and and Vol. VIII. Parts 1-8. Nos. 64-68.

South Staffordshire and East Worcestershire Institute of Mining Engineers.—Transactions. N.S. Vol. 1, 2. 1875-6.

South Wales Institute of Engineers.—Proceedings. Vol. 10. Parts 6 and 7. Vol. 11. Parts 1, 2, 3, 4, 5. 1876-7. From the Institute.

The Owens College Calendar. Session 1878-9. From the Council.

Transactions of the North of England Institute of Mining and Mechanical Engineers. Part 6. Vol. 27. Vol. 28. 1877-8. From the Council.

Watford Natural History Society.—Transactions. Vol. 1. Parts 6 to 10. Vol. 2. Part 1. 1877-8.

Books Presented by the Authors.

Dawkins, W. B., F.R.S.—Record of the Sub-Wealden Exploration.

De Rance, C.E., F.G.S.—Superficial Geology of the Country adjoining the Coasts of S.E. Lancashire. 1877.

Dickinson, Joseph, F.G.S.—Report on the Home Farm Inundation in June, 1877.

Report on the Blantyre Explosion in October, 1877, with Mr. Dickinson's Notes.

Reports on the Inspection of Mines in North and East Lancashire, for 1877, by J. Dickinson, H. M. Inspector of Mines.

Harrison, W. J.—Geology of Leicestershire and Rutland. 1877.

Hull, Edward, M.A., F.R.S.—The Physical Geology and Geography of Ireland. 1878.

Kinahan, G. H., M.R.I.A.—Manual of the Geology of Ireland. 1878.

Ricketts, C., M.D., F.G.S.—The condition existing during the Glacial Period. pp. 29. 1878.

Annual Reports, from the Committees.

Birmingham Free Library, 1877.

Chester Society of Natural Science, 1877-8.

Devon and Exeter Free Library, 1877-8.

Dundee Free Library, 1877.

Geologists' Association, 1877.

Leeds Naturalists' Club and Scientific Association, 1876-7-8.

Manchester Scientific Students' Association, 1877.

Manchester Field Naturalists' Society, 1877.

Royal Institution of Cornwall, 1878.
Salford Royal Museum, Library, and Parks, 1876-7.
Warwickshire Natural History Society, 1878.
Warwickshire Naturalists' Field Club, 1877.

AMERICA.

Agassiz, Alexander.—Museum of Comparative Zoölogy, Cambridge, U.S.A.

Bulletin. Vols. 4, 5, and Nos. 1-6. Vol. 6.

Chamberlain, T. C.—Geology of Wisconsin. Survey 1873-7. Vol. 11.
Cones, Elliott.—Fur Bearing Animals, 1877.
Connecticut Academy.—Transactions. Vol. 3. Part 2. Vol. 4. Part 1.
Hayden, F. V.—Bibliography of North American Invertebrate Paleontology. 1878.

Bulletin of the U. S. Survey of the Territories. Vol. 7. 1878.

Bulletin of the U. S. Entomological Commission. Illustrations of Cretaceous and Tertiary Plants. 1878.

Bulletin of the U. S. Geological and Geographical Survey. 1874-5, 1875-6, 1876-7.

Ninth Annual Report, 1875.

Preliminary Report of the Field Work in 1877.

Map, showing the Triangulations of 1877.

Geological and Geographical Survey of Colorada.

Selwyn, A. R. C., F.G.S.—Geological Survey of Canada. Report of Progress for 1877.
Smithsonian Institution, U.S.A.—Annual Report for 1876. From the Council.
Transactions of the American Institute of Mining Engineers. Vol. 5. 1876-7. From the Council.

AUSTRALIA.

Catalogue of the Free Public Library, Sydney, New South Wales. From the Royal Society, Sydney, N.S.W.
Journal and Proceedings of the Royal Society of New South Wales. Vol. 10. 1876.

Progress and Resources of New South Wales.

Report of the Mining Department of New South Wales. 1876.

The Climate of New South Wales.

Canada.

Canadian Journal. Vol. XV. Nos. 1, 2, 3, 4, 7, and 8. 1876-8.

Foreign.

Société Malacologique de Belgique. Annales. Tome XI. 1876. From the Society.

Procès-Verbaux des Séances. Tome VI. 1877. Pp. i.-cx.

R. Accadamica dei Lincei. Transuntis. Vol. II. Fasc. 4-6. 1877-8.

Società Toscana di Scienze Naturali. Atti. Vol. III. Fasc. 1. 1877. From the Society.

Broeck, Ernest Vanden.—Sur l'altération des roches quaternaires des environs de Paris par les Agents Atmosphériques.

Brongniart, Charles.—Sur la découverte d'un Orthoptère Coureur de la famille des Phasmiens dans les Terrains Supra-Houillers de Commentry (Allier). (Protophasma Dumasii.)

Sur un Nouveau Genre d'orthoptère Fossile de la famille des Phasmiens dans les Terrains Supra-Houillers de Commentry (Allier). (Protophasma Dumasii.)

Bulletin Société Vaudoise des Sciences Naturelles.—Sur Quelques Dipteres Tertiaires. Vol. XIV. Nos. 79, 80. 1877-8. From the Society.

Société Géologique du Nord. Lille. Annales. Tome IV. 1877. From the Society.

Verein fûr Erdkunde zu Halle, S., Mittheilungen. 1878. From the Society.

Naturwissenschaftlichen Gesellschaft Isis in Dresden.—Sitzungsberichte. Parts 7-12. 1877. From the Society.

Naturforschenden Gesellschaft zu Leipzig. — Sitzungsberichte. Jahrgang 4. Parts 2-10. 1877. From the Society.

BOOKS PURCHASED, 1877-8.

Geological Magazine. 1878.

Geological Record for 1876.

Geology of the Country around Blackpool, Poulton, and Fleetwood; also the Geology around Southport, and between Liverpool and Southport. By C. E. De Rance, F.G.S.

Mining Machinery. By G. G. Andre. 2 vols., ryl. 1877-8.

Mont Blanc. E. V. Le Duc. 8vo. 1877.

Palœontographical Society.—Monograph. Vol. 32. 1878.

Voyage of the "Challenger:" The Atlantic. Sir C. W. Thomson. 2 vols., 8vo. 1877.

West Yorkshire. By Davies and Lees. 8vo. 1878.

Zeitschrift für, das Berg. Hatten und Salinen-Wesen. Parts 2, 3, 4, Vol. XXIV., 1876. Parts 1-6, Vol. XXV., 1877. Parts 1-4, Vol. XXVI, 1878.

Societies with whom the Society Exchanges its Transactions and Institutions and Journals to whom a Copy is sent Free.

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VII.—Scientific Journals, &c.

Geological Magazine, Geological Record, Quarterly Journal of Science, Mining Journal, Colliery Guardian.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XV. SESSION 1878-9.

AN ORDINARY MEETING of the Members of the Society was held on Tuesday, the 26th November, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN EDWARD FORBES, F.G.S., President,
in the Chair.

The PRESIDENT, before proceeding to the ordinary business of the meeting, said he must, in the first place, thank the members for the honor they had done him in electing him President of the Society for the coming session. He regretted, on account of long illness, he was unable to continue the office as an Hon. Secretary of the Society, whose duties it had been his pleasure to assist in for many years past; but, in the coming year, he hoped, with renewed health, to take that position which had been awarded him.

Messrs. Thomas Ashworth, Mining Engineer, 40, Lancaster Avenue, Manchester; Samuel Cowell Atkinson, Stand Lane Colliery, Radcliffe; W. N. Atkinson, one of Her Majesty's Inspectors of Mines, Chilton Moor, Fence Houses; Thomas Brocklehurst, Colliery Proprietor, Dean, Bolton; John S. Burrows, Atherton Collieries, near Manchester; W. J. Greener, Pemberton Colliery, Wigan; John Laidler Hedley, one of Her Majesty's Inspectors of Mines, 3, Elm Vale, Fairfield, Liverpool; George Henry Hollingworth, Hollin-

wood, near Manchester; John Howell, Colliery Manager, Astley, near Manchester; Charles Gidlow Jackson, Mining Engineer, Wigan; Sampson Maiden, Colliery Proprietor, Bridgewater Villas, Stockport; Miles Settle, Snow Hill, Darcy Lever, near Bolton; and William Henry Statter, Town Hall, Bury, were elected ordinary members of the Society.

GYPSUM IN THE BOULDER CLAY,

The following communication was read:—

"Manchester, October 31st, 1878.

"Gentlemen,

"I beg to send you for addition to your Museum, should you consider it of sufficient interest, a block of gypsum found, with many others similar, some 18 to 22 feet below the surface in the excavation for foundations of the Southern Abutment of the Viaduct recently constructed for these lines at Radcliffe.

"There may have been a cube yard of the deposit—the whole consisting of these nodules or blocks; this fact indicating that they were transported by some agency, probably water, from the formation from which they became detached, and deposited in the boulder clay at a very early stage of this stratum—shale and rock being very near below.

"Save such pieces as I secured for specimens, I believe the whole of what was raised was carried away by the people residing in the neighbourhood; and may now be seen (some made to show a very nice section) ornamenting the window sills and rockeries of the houses as far as Black Lane.

"Yours very truly,

"THOMAS J. NICOLLS,

"Resident Engineer.

"The Hon. Secretaries,

"Manchester Geological Society."

Mr. DICKINSON said: I think this specimen, and the others which are alluded to, have come from a part of the country which on the geological map is marked "Banks of sand resting on boulder clay." The fact of finding that specimen of gypsum near to Radcliffe would lead one to suppose that what is called boulder clay on the geological map is really the Permian marls, of which we have some fine sections in the valley of the Irk. It is next to impossible that all those blocks could have been carried from the Irk towards Radcliffe. It seems to me undoubted that the direction in which all the drift has come is in exactly the opposite direction—from north-west to south-east—and, if that be so, it seems not unlikely that a large portion of the geology of Prestwich—all through Heaton Park and Whitefield to Radcliffe—will have to be re-cast; that those clays which have not been considered as Permian will have to be so marked; and that the immense deposits of sand and marl overlying that country can have come from no other source but either the Permian or the new red sandstone. In the Transactions of this Society, Vol. I., published many years ago, there is a paper, which was read by Mr. Binney, on the Geology of Manchester and its vicinity. In that paper a section is given of a boring in the township of Clayton, made by the late Mr. John Bradbury, according to which amongst the variegated marls is a bed of gypsum nine inches thick. The section is given as rendered by Mr. Bradbury, but Mr. Binney appended the following note: "I believe that this is merely termed gypsum from its white colour." At that time I don't think the geology of these Permians was as well known as it is now. I have myself seen the cores taken out of a bore-hole, made by the Diamond borer, in which the deposits of gypsum are perfectly plain, in the township of Clayton; and the finding of the blocks at Radcliffe shows that the Permian of this district does contain gypsum.

Mr. W. J. Grimshaw: I have a number of specimens from the same place. They are of diversified forms; some are rounded, almost like brook pebbles, whilst others are extremely angular. I have had them tested, and there is no doubt as to their being gypsum. I may mention that a gentleman with whom I have been in correspondence has a theory that these blocks have been formed through chemical action from some deposit in the clay. He does not believe, considering the diversified forms of these boulders, that they have been deposited *in situ* from any great distance.

Mr. Dickinson then took the chair, the President being obliged to leave.

TIMBERING IN MINES.

By W. J. Grimshaw, F.G.S.

The subject is one regarding which, but little is to be said that is not generally known. However, a few notes, roughly jotted down may be of use occasionally, being brief and simply referring to one general subject. In most instances, pit-head frames are made of timber, so we may safely take as a starting point the material of which they are constructed, noting the mode of fitting them together.

Pit-Head Frames.

The timber generally used is memel or pitch pine—clean, free from knots, and sap. Pitch pine seems to be the best, for on several occasions which have come under the writer's notice, where mixed timber had been used in the construction of a headgear, the red or white deal had to be renewed while the pitch pine pieces were perfectly sound. The resinous nature of pitch pine enables it to withstand a great amount of weathering. The strength of the timbers used is

a matter for calculation. Double tenons are certainly best, and joint bolts add much to the stability of the structure. All diagonals and trusses should be joint-bolted and beneath every transverse stay a tie bolt should be put. If a headgear stands upon the surface of the ground it is advisable to fix the uprights and back-spurs in sills, kept apart by cross-pieces, but if the headgear is elevated and rests upon pillars, the vibration of the sills is often a disadvantage, more especially when it is not possible to stay them very closely from below. The headgear should be entirely clear of the engine-house or any other buildings.

Pump Rods.

There is some considerable difference in the strength of rods required for "forcing" and "draw" lifts. For a "ram-pump" of 21 in. diameter for 90 to 100 yards of a lift, the rods are usually of pitch pine 14 in. square, and lengths as long as are possible are obtained. For a ram-pump 18 in. diameter rods 12 in. square are generally used, and for a ram-pump 14 in. diameter 10 in. square, the column being about 100 yards. For a bucket or draw-lift of 12 in. diameter, rods about 6 in. square are sufficient, care being taken to get the timber as straight balked as possible, and free from knots, sap, and cracks.

Steam Pipes in Shafts.

A metal plate placed between the timber stays and the pipe is advisable, as even if the pipes are covered certain action results from the contact.

Shaft Timbering.

Horse-trees or bearers of English oak are often used, as are ring pieces also. By shot firing there is not the same danger of breaking a wood ring that there is of snapping a cast iron ring, as the writer has found out to his cost.

[redacted]

pitch pine with cross or frame sleepers of larch is an arrangement that answers well when the dip is steep. In walling underground engine-houses with dressed stone, boards of larch, about 1 in. thick, placed between the courses at intervals instead of mortar are found to prevent the breaking and cracking of the stone to a considerable extent in case of weight coming on.

Timber in Working Places.

In highly inclined seams, it certainly seems best for the miner to have an easily handled prop, of sufficient strength to make his place secure. As a rule, miners who choose their own timber pick the lightest and the most easily handled. This is very foolish in many cases, and is seldom a saving of labour, for the weak props get broken and have to be removed, taking more time eventually than would have been required to set up a sufficient prop, besides being a source of increased risk. Theoretically, oak props are the best, but oak is so crooked as a rule, that all the advantage it has, considered simply as a timber, is lost. It is well known that there is most economy in a good supply of timber of the best kind and most adapted to the wants of the miner. Small caps are a great mistake, for we often find that a good cap will save a sound prop. Caps ought not to be cut wedge-shaped; if it be so cut, we find that a prop is at its "set" before it is at right angles to the roof and floor of the mine. If the prop is driven up until it is at right angles, it is then beyond its proper "set," and consequently only supports the roof by about one-half of the prop head. The most natural way of setting props seems to be with the thick end on the floor, as the trees grow. They are often set the reverse way; but the writer is inclined to think that they will support more weight, if set in the latter fashion. Props set moderately close, are more easily recovered, than when sparsely distributed. It is a mistake

to calculate upon supporting the roof for any considerable time upon props. Pack walls should be put in, or chocks built, and such props as can be spared, taken out. In Long-wall workings, chocks, at the junction of roads, generally answer much better than props. "Stretchers" consist of two props, one on the "high" and one on the "low" side, connected by a cross-bar, which is usually a little flattened at each end, where it rests upon the props or legs. Pieces are put on the "bars" or "stretchers" when needed, and if any cavity exists, small dirt is filled immediately on the "ricing" or "lacing" timbers, larger pieces being filled thereupon. If a large cavity exists above the timbering it is not advisable to load the bars in the centre as heavily as on the sides, the centre being the weakest place. It is certainly questionable to what extent it is advisable to load bars to fill up the space above. A comparatively small fall of roof will break down the bare timbers, whereas the same fall alighting upon a layer of small dirt, might not cause any material damage.

If a certain vacant space is left above the timbering of a road, it often affords a lodgment for gas, and it is by no means easy to ventilate such a space, or, as it is often called, a "lofthead," in all cases. If bars are heavily loaded, it is not a very easy or safe operation to renew the legs in case of necessity. The matter seems to stand thus:—

Leave your timbers bare and a fall may break them, also gas may lodge above them. Pack them partially with small dirt and a fall would not be so likely to break them, still gas is more likely to lodge in such cavity as may be left.

Pack them heavily, and you are throwing undue dead weight upon them, and rendering them liable to be immediately affected by any pressure, besides being more difficult to deal with in case of needed renewal. Some objection may be found to every course.

Two kinds of couplings are in general use, the notched, which retains pretty nearly the whole of its strength, and the mortised bar and tenoned leg, in which there is a considerable waste of timber and weakening of carrying power.

There is not the same stability in the notched couplings, that there is in the mortised, until the weight comes on. They are somewhat liable to cant under certain circumstances, but are much more easily drawn. The mortised couplings are more difficult to set, but are not so easily knocked out, in inclined measures. They are well adapted for jig brows and engine planes, and are calculated to resist much greater lateral pressure than are the others. For general use the legs and couplings known as "slotted," are as a rule reliable, steadfast, and simple in erection.

We may banish theory in details from our systems of underground timbering. Broadly accepted, theory is useful, but contingencies so often arise, which need immediate dealing with, that no time may be spared for minute and ordinary calculation, which calculation, if duly performed, is more often likely to be wrong than right, simply because our knowledge of data and local circumstances is deficient entirely, and unreliable altogether.

In putting in water-dams of pitch pine, the wedges of pitch pine well cleaned, will be found to enter more freely if the joints are rubbed on a red-hot iron.

Preservation of Timber.

Comparatively speaking, but few instances of the usage of solutions, to preserve timber have come under the writer's observation. Still it may not be amiss to draw attention to a few of the most well-known processes used for that purpose:—The "Kyan" process consists in saturating the wood with a dilute solution of corrosive sublimate. "Margery" used acetate of the sulphate of copper. Chloride of

The migration of these pebbles is seen to be from the south-west to the north-east as the south sides of the Groynes are heaped up by the wind waves that drive them from the south. Curiously there are no pebble banks in Portland Bay just now, but Leyland says, there was in his time (1500), a pebble bank or spit stretching from Wyke Point south-east to Portland, and that the exit of the Fleet River, which flowed between the two banks, existed there then.

This bank again may be considered as a development of a bar that formerly obstructed the mouth of the river Wey, when it opened out into the sea further south, and probably was a portion of the Chessil Bank itself driven in by the storm waves when the Portland Strait was open.

The basis of the Chessil Bank was found on boring by Sir John Coode to be blue clay, but this existed only on the east, or Portland side of the bank, and not on the west, or Lyme Bay side, and the soundings in the former indicate mud, sand, gravel, and shells, and in the latter sand, gravel, and accasionally rock, but no shingle pebbles.

In Sir John Coode's communication to the Institute of Civil Engineers, May 5, 1853, (Vol. 12, Proc. In. Civ. Eng., 1852-53,) will be found a full description of the length, breadth, shape, size, with dimensions in feet, of the Chessil Bank, along with his views on its history and formation, and a most remarkable and instructive discussion therein is reported on it. It appears to be about 9-10 miles long; opposite Abbotsbury, 540 feet broad at low water, and 35·3 feet high, above same level, and 71·3 feet from the clay bases; opposite Fleet, to be 590 feet broad at the base, 37·6 feet high, above low water, and 79 feet above the clay bottom; and at Chessil Town, 600 feet broad at base, and 55·9 high, above low water, and 103·3 feet above foundation. The slope of the bank on the sea side, from top to low water, is at Abbotsbury 1 in 7 feet, and Portland 1 in 5½ feet, and at

low water the slope is at Abbotsbury, 1 in 11 feet; and at Portland, 1 in 8 feet; and further out in the bay beyond 2 fathoms depth, it is 1 in 30 feet; as far as 6 fathoms at Abbotsbury, and 8 fathoms at Portland.

The bank is composed of rounded stones and ovoid peebles of chalk flint and chert, these being the most numerous, and then come those of red sandstones, porphyry, and jasper, the former derived from the chalk cliffs and valleys of Dorsetshire, at Abbotsbury, Chidcock, Charmouth, Lyme, Sidmouth, Salterton; and the latter from the New Red beds, scattered along the coast at Axmouth, Weston, Sidmouth, Otterton, and Exmouth.

The following are the dimensions of some pebbles collected from the bank and their specific gravities, ascertained by Dr. Stevenson Macadam, of Edinburgh:—

Stones.				Peebles.			
	oz.	oz. of water.	cnb. inch.		grs.	grs. in water.	
1.	13¼ —	5·5	.. with 10·2 bulk.	1.	1063—683	.. 2·54	spec. gravity.
2.	10⅜ —	5·5 to 6·6	„ 9·8, 10.2 „	2.	960—589	.. 2·58	„
3.	8¼ —	1·5	.. „ 3 „	3.	838—505	.. 2·51	„
4.	8½ —	1·5	.. „ 2·8 „	4.	707—438	.. 2·63	„
5.	4¾ —	1	.. „ 2 „	5.	732—445	.. 2.54	„
	mean Sp. gravity 2·56.			6.	826—508	.. 2.59	„
6.	3¼						

Total weight of 6 stones 54½ oz., total fl. oz. water 20·3—21·2—21·5 oz.= mean 21 oz., total cubic inches 30·5, average specific gravity 2·68—2·53= mean 2·60.

The bank however is not entirely composed of stones and pebbles, but at a depth of 10-15 feet below the top surface, Sir John Coode found by borings sand intermixed which increased so much in quantity in descending that at 18-20 feet deep the latter was found solid and packed, so that the bank was discovered to be perfectly impenetrable to the tides from Lyme Bay.

It is highly probable that the bank has grown in length and height, and breadth, from ancient times, as may be

inferred from the following quotation from Leland, Vol. 3, p. 66: "As often as the wind bloweth strong at south-east, so often the sea beteth it, and loseth the bank, and breaketh through it, (which would be impossible now altogether) so that if this (south-east wind) might continually blow, then this bank should soon be beaten away, and the sea fully enter, and divide Portland, making it an isle, as surely and by it in times past hath beene. But as much as the south-east wind doth bete, and break off this Chessill bank, so much more doth the north-west wind succur, and strengith, and augmentith it."—Henry 8th reign; died 1552; 300 years.

Leland attributes the destructive action to the south-east winds and the constructive action to the north-west winds, but Sir J. Coode considers the former action to be due to ground swells occasioned by or following gales from south-east, east and north-east, but he does not state the wind that follows the subsidence of the gale, neither is there any very clear description to be found, as to the course and direction of the surf, whether the lines of its crests are parallel, oblique, or at right angles to the line of beach.

We gather, however, that the ground swells after gales from any quarter are destructive to the bank, clear away its accumulations, and scour down the front slopes, so as to expose the foundations of the Blue Kimmeridge Clay, and the spoils of the tempest are then gathered by the fishermen watching the recession of the water.

On Nov. 23, 1852, a ground swell of 18 hours' duration removed 4,553,000 tons of Pebbles; and it required five days afterwards to restore 3,553,200 tons of Shingle to the bank.

These ground swells should probably be interpreted as the back trochoidal action of the wave oscillation, as stated by White (in Journal, Unit. Service Instit., Vol. 21, 1877, No. 22, p. 937,) when the particles of water in the crest move in

the direction of the wave's advance, and at the hollow the particles move in the backward way, or against the advance of the crest or out to sea.

It may further be stated that the scouring effect of this back action must be increased by the depth of the trough of the wave below the mean sea level, as the particles of water would have their momentum increased by a fall from the top of the crest of wave of several feet (6-12) to the bottom, and also on the trochoidal theory by the particle having below this line taken on centrifugal force, in addition to that of gravity, in the course of its revolution round its orbit of oscillation having its axis placed at the mean sea level.

Sir J. Coode again states that slow waves of seven or less per minute have a destructive action, and that fast waves of 8-9 or more per minute had an accumulative action on the shingle of the bank, without stating that these were dependent on any particular wind. These actions may be explained by the terms proposed in my note on Rolled Pebbles, in the Transactions of the Geological Society, of Edinburgh, for 1876, where it is shown that the next fast wave again strikes the pebble upwards before it has completed its full descent down the bank, after the recession of the first wave. But during the action of the slow waves the pebble would have ample time to descend by gravity rolling it down the slope, aided by the backwash of the retiring surge.

It should always be considered that the violence of the wind blowing in the same direction as the advance of the wave will aid the accumulative action by driving the water and pebbles before it, but if the wind should be north-east or from the land, with a heavy ground swell of the sea on, as Leland says, then the wind will be with the backwash of the surf, and drive it and the pebbles down to meet the advancing crest, and fearful breakers would result. Sir J. Coode, who

was Resident Engineer of the Portland Breakwater, says that the prevalent winds with greatest wind force are those from south-west and a-half west, which agree closely with a line drawn perpendicularly to the axis of the centre of the length of the bank, and, therefore, points to the direct action of the waves created by south-west gales and breezes as being the chief builders of the Embankment.

The question of the origin of the Chessil Bank being still a matter for discussion, these remarks tend to controvert the theory of its formation by tidal action and currents, as maintained by many eminent geologists.

Extract from a letter,—Mr. R. T. Smith, geologist, Weymouth, Dec., 1877,—about the Chessil Bank during the last year :—"The gales have been mostly from the south-west, and I do not hear that the shingle has been removed more than at other times. What fishermen call a ground sea often takes away the beach, and at those times, coins, Spanish gold and silver, are often found in the clay and shingle below the beach in what they call "hard" (*i.e.*, the base). I have not heard of any coins having been found this autumn. There have not been any wrecks on the beach this season, but some of the men from the collision of the Forest and Avalanche were landed on there. Several things are often thrown up on the beach from the wreck of the Royal Adelaide, and I had brought to me a few days ago two horse shoes with iron nails, copper nails, links, shirt buttons, &c., mostly corroded and glued together by rust. Bronze celts have also been found under the beach after a heavy ground sea has exposed them. A heavy ground sea would sometimes take place in the west (or Lyme) Bay during the fog, without wind at all (probably easterly fog in the channel).

ON A TOOTH OF *RHINOCEROS TICHORHINUS* FOUND AT THE ENTRANCE TO THE PEAK CAVERN, CASTLETON, DERBYSHIRE.

By Mr. Rooke Pennington, F.G.S.

The stream which issues from the mouth of the Devil's Cavern (now better known as the Peak Cavern,) at Castleton, receives two important tributaries before it leaves the deep gorge into which the cave opens. One of these affluents is the powerful spring known as the Russet Well; the other is an intermittent brook flowing from the west and appearing in daylight from beneath the embankment along which the road to the cavern is conducted. The Peak river, as it emerges from the cavern, is a combination of two main streams, one of which is identical with that seen in the Speedwell Mine; the course of the other is not accurately known, but it, doubtless, like the Speedwell brook, comes from the depression between Rushup Edge and Elden Hill, that is between the roads to Buxton and to Chapel-en-le-frith, a depression from which there is no surface outlet, and from which many rivulets seek escape by means of underground channels. The intermittent brook I have referred to, in all probability, flows from the same neighbourhood. Although water-less in dry weather, a rainy day or two gives rise to a considerable flow and as each rush subsides, its bed (which is artificially confined by banks) is encumbered with limestone fragments, calc-spar sand (such as comes from lead mines) splinters of bone, and fragments of blue-john spar.

During last Spring, a child (the place is a favourite resort of the village children,) found in the then dry bed, two or three pieces of fluor spar, and what it thought was a curious stone. The curious stone was the tooth of a woolly rhinoceros, and was at once recognised on being brought to me. On carefully examining the place, I found such *debris*

above described, but neither then, or on subsequent visits, any other tooth or bone that could be specifically identified.

I have no doubt that the tooth has either been washed out from some of the numerous fissures in the limestone which contain mammalian remains, or from some cave, where, possibly, its owner was eaten by hyænas. So far as local experience goes, the former is the more likely. I do not know that any hyæna-den has yet been discovered in the mountain limestone district of Derbyshire, nor has any trace of the hyæna itself been found in that area, unless it be in a recent "find" at Matlock. I am glad to find that a history of this discovery is to be given us to-day.

The Peak cavern mentioned is probably one of those where the animal died in the summer, its remains being carried by flood or stream to a resting-place in a fissure, till the destruction of the walls of the fissure by the chemical and mechanical action of water once more disturbs the sepulchre, and the bones and teeth are washed out to lower levels, or, as in this case, into daylight again. No inference as to the Peak cavern having been a dwelling-place of either man or beast can be drawn.

This is by no means a solitary instance of the finding of rhinoceros remains in the district, but it affords one additional proof of the residence of this animal in central England during *recent geological times*.

ON BONES OF PLEISTOCENE ANIMALS FOUND IN A BROKEN-UP CAVE IN A QUARRY NEAR MATLOCK, DERBYSHIRE.

By Mr. Robert Law.

In July last I went on an excursion for the day to Matlock Bath, accompanied by two friends. With a view of collecting fossils, we visited Boden's Quarry, where we accidentally

picked up a molar tooth of *rhinoceros tichorhinus*, which led to our finding a cave, the entrance of which was about 20 feet above the level of the river. On searching carefully, we soon found a tooth of a *cave hyæna*, a portion of the lower jaw of a *fox*, and several broken leg bones, probably of the *reindeer*.

Some weeks afterwards I again visited the place, provided with the tools necessary for making a careful and thorough examination of the *debris* in which the bones above referred to were found, and after having obtained the necessary permission from Mr. Boden, I commenced work in good earnest.

The *debris* or deposit referred to, was about 50 feet long, and from 1 to 5 feet thick. It was situated in the north side of the quarry, and rested on a ledge of greyish lime-stone, about 15 feet from the ground, which ran nearly east and west, the dip being about 18 degrees to the eastward, and which corresponded closely with the floor of the cave.

The excavation was carried out with the utmost care, and occupied three days, from early morn till night.

The following is a section of the deposit in the centre where it was thickest.

1. Reddish brown rubbish, 1 foot thick, very loose, with imbedded angular fragments of limestone varying from one to thirty pounds in weight. Bones were entirely absent in this layer.

2. Dark loamy sand, 2 feet 6 inches thick, consisting of alternating layers of lightish brown and greyish black colour, the layers varying from 1 to 2 inches in thickness, and apparently composed of particles derived from lime-stones and toadstones. Bones were also absent in this bed.

3. Red clay, 4 inches thick, rich in osseous remains.

4. Yellowish grey breccia, 14 inches thick, consisting of angular fragments of limestone imbedding a considerable number of bones, principally in fragments.

The method of procedure was to cut down a portion of the *debris* at a time, from top to bottom, generally about 2 feet in length and 4 feet in width, removing and carefully examining each layer separately, in order to ascertain with precision the bed from which each bone had been obtained. In this way I cleared the *debris* from the ledge of rock for a distance of 18 feet.

From personal observation, and enquiry from the quarrymen and others, I am satisfied that the cave at one time extended a little further eastward than at present, a portion of its southern side and top having been quarried away, thus bringing its long-hidden contents to light. The cave could not have been known before the quarry was worked, as the original entrance was then overlaid by a superficial deposit from 3 to 4 feet in thickness, consisting chiefly of small angular fragments of limestone, overgrown by part of the wood, now covering the eastern declivity of a hill known as the Heights of Abraham.

In my opinion the bones (now exhibited on the table) have been carried from neighbouring sites into the cave, and there deposited, by aqueous agency. My reasons for so thinking are formed from the following considerations:—

1. The cave, running at right angles to the course of the river Derwent, may have been frequently flooded by it when flowing at a former level.

2. The finding of a well-rounded pebble in the breccia, probably micaceous sandstone.

3. The bones showing little or no signs of gnawing.

4. The absence of any trace of man or his works in the deposit, so far as yet investigated.

5. The bones found in the red clay deposit being, in nearly all cases, in a perfect condition, while those in the breccia generally occurred in fragments.

6. The layer No. 2 mentioned in the section having a stratified appearance, thus pointing to the action of water.

The several bones which I found have been submitted to Professor Dawkins, (to whom I am much indebted for his kindness), who has identified them as belonging to Rhinoceros tichorinus, Cave Hyæna, Bear, Reindeer, Fox, Red-deer, and Bison.

THE MAMMOTH AT NORTHWICH.

Prof. Boyd-Dawkins, F.R.S., said: Mr. President, the note which I have to bring before the Society this afternoon relates to a discovery which was made last Spring by Mr. Bloxsom, the engineer of the New Victoria Salt Company, near Northwich. It appears that, in sinking a shaft, they exposed a section as follows:—First, there was 2 ft. of soil; then 9 ft. of brown sand and clay; then 37 ft. brown boulder clay; and finally 32 ft. of fine sand, which rested upon the red marl containing the layer of rock salt, for which the shaft was sunk. Whilst they were making the shaft, the travelling cylinder intersected the tooth of "some gigantic animal;" at a depth of 16 ft. below the surface of the sand. The importance of this discovery is twofold: first of all, it brings the range of the mammoth as far to the west—in this part of the country—as Northwich. But the most important point is that the sand in which the tooth was embedded clearly and distinctly underlies the lower boulder clay. Near Bowdon we have the middle drift sands resting upon it, and approachng nearer to Manchester we get the upper boulder clay series. Thus it will be seen that by this discovery we have the fact clearly established, that the mammoth lived in this country at a period before the deposit of the lower boulder clay, or in other words in pre-glacial times.

I have used the term "pre-glacial" with a certain amount of fear and trembling, because, in these days of highly com-

plicated glacial classifications, in which nearly everyone who writes about the boulder clay takes the particular district which he has examined to be the key to the whole, and arranges the whole of the boulder deposits in one linear series, it is very difficult indeed to attach a distinct and decided meaning to the term "pre-glacial." In using the term, I merely mean that it is older than the oldest boulder clays that are to be observed in this district. I might here remark that I entirely disagree with those gentlemen who arrange the boulder clays of Scotland, Lancashire, and the eastern counties in one linear series. I see no reason for doubting that, during the time when the Scotch "till" may have been forming, under the pressure of enormous masses of ice, in the mountainous districts of the North, icebergs were depositing the boulder clays in the area of Lancashire and Cheshire. While there were icebergs and glaciers at work in Wales and Cumbria, and in Ireland, surely there were some glacial agents at work on the other side of the Pennine Chain, in the eastern counties, and if so, the linear arrangement is wrong. A classification of boulder clays by an appeal to their physical character is worthless. It seems to me that, speaking in general terms, there are three great phenomena to be observed in the general glaciation of this country. There is, first of all, the great period of land ice and sea ice, when the lower boulder clay series was accumulated. Then there was the great period of depression so admirably described by Sir Charles Lyell, and which is universally recognised by the leading geologists of the day, during which the middle glacial sands were deposited; and, lastly, we have the upper boulder clays of Lancashire and Cheshire, and also the moraines and other glacial marks which are to be noted in the hills of Wales and the hilly districts of Cambria and of Scotland. Other than these three divisions

I cannot see my way, in the present state of knowledge, to accept in any other sense than mere parochial divisions. The important point in the discovery at Northwich is that the mammoth was certainly in this part of the country before the older boulder clay was accumulated over the sands in which its remains were entombed. Remains of the mammoth have only, up to the present time, been found in the district, on the one hand, in the superficial gravel,—as I believe, though there is no accurate information, at Copenhall, near Crewe. The specimen, a tooth, belongs to Sir Philip Egerton, and is now in his collection. A tusk of mammoth has also been found in a fissure in the mountain limestone at Doveholes, near Buxton.

Professor Dawkins, in opening the discussion upon the several papers, said he was not able to contribute anything of importance to the admirable description which Mr. Law had given of remains found at Matlock. With regard to the remains on the table he had only to remark that the bones of the hyæna were exceedingly few, and the condition of the bones, generally, indicated that carnivorous animals could not have been at work upon them to any great extent. With one exception all the bones are free from the marks of teeth. One bone, only, bore clear and distinct traces of gnawing. With regard to the mode in which these bones were introduced into the cavern there was no doubt, in his mind, that Mr. Law's view was the correct one. He had never been able, in the course of his experience, to account for the abundance in some caverns, of bones which were very nearly perfect—hollow bones, containing marrow—without the interposition of water as the introducing agent. In such a case it was clear hyænas could not have had access to the carcases, because if they had, the bones would have been gnawed to pieces, as we find in all the hyæna caves of Europe. But

undoubtedly the hyæna was in that neighbourhood, and he would be inclined to believe that the hyæna bones found at Matlock were introduced into the fissure by the same agency that introduced the remains of the other creatures. Mr. Law had mentioned amongst the remains, those of the bear. The fragments were too insignificant to enable him (Professor Dawkins) to say anything as to the species. He would merely say that in all probability, the remains did not belong to the great cave bear. They were very closely allied to the bears whose remains were found in Windy Knoll, near Castleton. The majority of the remains belonged to the reindeer, and a few of them to foxes—the foxes being comparatively rare as compared with the reindeer. The bison, however, in this cavern, was merely represented by one or two fragments, which was a very curious thing when one considered what vast quantities of bison bones were obtained by Mr. Pennington and himself (Professor Dawkins) at Windy Knoll. With regard to the relation of these bones to the glacial period, he did not know that they had any evidence, but certainly, from the general current of his observations, during the last few years, he thought that ultimately there would be reason to believe that the great majority of the caverns containing bones, in the Pennine Chain, were inhabited before the glacial phenomena began in the district. On that point, he thought Mr. De Rance had met with some evidence, with regard to the bison, in North Wales. He thought, that the view which Professor Phillips advanced many years ago that large numbers of ossiferous caverns in this country were of pre-glacial age, was the view which we should probably have to accept. At present we had no decided evidence on the point, and this being the case, it was very much safer not to indulge in any of that exercise of the imagination which had caused so much mischief to geological science.

Mr. Rooke Pennington said that having heard of the discovery at Matlock, and made inquiries in the locality, his view coincided with that brought forward by Mr. Law, that the bones had been introduced by the action of water. He (Mr. Pennington) would suggest to Mr. Dawkins that it was very remarkable that, although there was such a number of caves in the mountain limestone of Derbyshire, there was no real instance of a hyæna den having been brought to light. In the discoveries made at Wirksworth by the late Dr. Buckland—particularly that celebrated rhinoceros depicted in *Reliquiæ Diluvianæ*, (which appeared to be in perfect condition)—the remains had evidently arrived at their resting place by the action of water, and had not been introduced by any carnivorous animals. It was a remarkable thing that both at Windy Knoll, Dove Holes, Buxton, Matlock, Wirksworth—everywhere, in fact, throughout the mountain limestone district of Derbyshire, and the adjoining mountain limestone district of Staffordshire—that had been the case. In the discovery at Waterhouses the same state of things was shown: there was no reason to suppose that the cave had been the habitation of the hyæna; and this was, he believed, the first instance of the discovery of the hyæna at all in the country, except in those Permian caves which had been so recently thoroughly worked out by the conjoint experience of the Rev. J. M. Mello and Professor Dawkins.

Mr. De Rance said he would like to say a word with reference to the bison, discovered in North Wales, to which Professor Dawkins had alluded. At Prestatyn there was a steep escarpment of carboniferous limestone, which sloped away towards the lowlands about Rhyl, at the base of the limestone they had certain boulder clay, sands, and so forth. As good fortune would have it, there was a very

deep and considerable lead mine at Talargoch. In sinking some of the shafts of this mine they passed through the boulder drift, and at the point where they reached the rock, at the foot of that glacial drift, the particular bison bone which had been alluded to was found. In following those glacial drifts along the coast, as the Geological Survey were now doing, mapping the Flintshire coalfield, they found them to be continuous; and he had very little doubt that those particular deposits—deposits formed at the bottom of a glacial sea—which fringed the entire coast of Flintshire, would be found continuous with similar deposits in Cheshire, and even as far as Lancashire. He (Mr. De Rance) agreed with Professor Dawkins in the triple division of the boulder series. The lower boulder clay, however—at least what he called such—in Lancashire, Cheshire, Cumberland, and Flintshire, was, according to his observations, always a marine deposi. It contained exactly the same shells as were got in the upper boulder clay—two or three forms of mollusca, found in the middle sands, were absent from the lower boulder clay; but with that exception, the lower boulder clay indicated a lower, though not a greatly lower, temperature than the middle sands. Beneath the lower boulder clay there was found occasionally a dark clayey material which Scotch geologists would call "till"; and that oldest deposit of all—the till—was, he presumed, that to which Professor Dawkins alluded when he spoke of the lower boulder clay as of the terrestrial period, that till was an exceedingly local deposit. He only knew of it in five places; and it seemed to belong to that period of glaciation when we had glaciers in the Lake District of tolerable size, leaving moraines in the deeper valleys, with left fragments here and there, in odd corners, denudation having separated them.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XV. SESSION 1878-9.

An ORDINARY MEETING of the Members of the Society was held on Tuesday, the 28th January, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

Mr. Henry Baxter, Colliery Manager, Tyldesley; and Mr. Edward Gregson, Mineral Agent, Preston, were elected ordinary members of the Society.

The CHAIRMAN announced that arrangements have been made with the Council of the Literary and Philosophical Society, which entitle the members of this Society to make daily use of the Council Room on the right-hand side of the Entrance Hall, for the purpose of consulting books contained in the library, &c., subject to the convenience of the Council when holding meetings.

The CHAIRMAN announced the death, since the last meeting, of one of the oldest honorary members of the Society, viz.: Thomas Sopwith, M.A., F.R.S., F.G.S., Memb.Inst.C.E., Honorary Member Manchester Geological Society. Born at Newcastle-on-Tyne, January 3rd, 1803; died at Westminster, January 16th, 1879. Practised, during half a

century, as a mining and civil engineer; engaged in several extensive undertakings in this country and on the Continent; appointed Commissioner for the Crown under the Dean Forest Mining Act, in 1838; from 1845 to 1871 manager and agent of Mr. Wentworth B. Beaumont's mining property in Allendale; inventor and constructor of geological models of mining districts, for a paper on which, in 1842, was awarded the Telford Silver Medal by the Institution of Civil Engineers; author of a work on the Mining Districts of Cumberland and Durham, on Isometrical Drawing, Notes on Egypt; also of several communications to learned societies, and upon topics of a miscellaneous character. "His name will be long cherished as one of the not few sons of eminence to whom Newcastle has given birth."

Mr. PLANT said, in reference to the memoir just read, it ought to be known to all the mining members of the Geological Society that the Society possessed a set of the models which Mr. Sopwith constructed, and which he presented to this Society. They were now exceedingly rare and valuable. For beauty and perfection, and for the serviceable and practical purpose of illustrating a lecture, or for teaching in a mining college, they could not be excelled. They were accompanied by a small book, which fully explained the purport and intention of the models.

COAL IN ALLUVIAL SAND AT MOSTON.

Mr. COOK showed a piece of Cannel coal which was found recently at a depth of about 28 feet in the alluvial sand at Moston Colliery, in Failsworth, when making a railway cutting. He was unable to satisfy himself as to the locality from which it came, as the Cannel mine is about 150 yards deep at this point, and is apparently of a different quality.

Mr. GREENWELL said he had frequently seen pieces of coal in surface deposits, but they had invariably had the appearance of being water-worn. The piece now shown had not much the appearance of an old water-worn coal nodule.

The CHAIRMAN said it did not appear to have been subjected to rough usage; but it was quite common to find pieces of coal in the sand deposits of Cheshire. The large deposit at Sandbach Station, for instance, had coal in it.

Mr. GREENWELL: In the sand and gravel at Stockport there are also pieces of coal.

Mr. PLANT said that quantities of coal like that exhibited might be procured from the drifts between Manchester and Oldham. It was always cannel coal; he had never seen any of the soft bituminous coals. He accounted for it in this way: the greater portion of the surface of Lancashire had been scoured down by the action of ice—or whatever action did scour down the rocks—and there was embedded in the *debris* a great number of boulders, which belonged to the district, and the coal measures had also undergone that denudation. The fragments now found were simply those which had survived the wear and tear.

Mr. AITKEN said coal nodules were found extensively in the drift at Bacup. He at one time made a collection from a deposit of about 1000 feet above the sea level, but the nodules were, in every case, different from the one now exhibited. They were all more or less rounded, and of the character described by Mr. Plant, namely, bastard cannel. In no case did he find any bituminous bright coal. There was some difficulty in accounting for their presence in that position, as they differed in character from any of the coal deposits in the neighbourhood. Where they came from was a mystery he had not yet been able to solve.

EXPLOSIONS IN MINES.

The discussion on Mr. Wild's paper on "Explosions in Coal Mines," read at the June meeting, was resumed.

Mr. GREENWELL referring to that part of the paper which dealt with the relation between the quantity of gas given out by goaves and the quantity of air sent into a mine, said he should like that point cleared up. Mr. Wild's statement was contrary to all one's preconceived notions. It was that in a low state of the barometer the gas, instead of, as one would expect, issuing more from the edge of the goaf, disappeared into the goaf. He would like to ask Mr. Wild whether, in addition to the gas given off—light carburetted hydrogen—there was not also a good deal of carbonic acid, or stythe, also given off in the same mine; because it would then be perfectly possible that such a state of things as that described might occur; that although there might be gas in a certain proportion, yet neither the light carburetted hydrogen nor the carbonic acid gas being swept away by brisk ventilation, there might be at the edge of that goaf a mixture of a less explosive character than it would be if it was mixed up with fresh air in a larger proportion. He had seen instances of that himself. He had seen instances where from the mixture of stythe with the fire damp the mixture had been—if explosive at all—at any rate less explosive than that same gas when freshened up, so to speak, with an additional quantity of air. He simply put that forth as a question that might probably be worth considering, and he would like to hear if any gentleman had any facts which could account for what Mr. Wild said, which, at first sight, seemed incomprehensible.

Mr. WILD said that choke-damp, or stythe, had never been met with in the mine of which he spoke. The only

explanation he could give was that it was owing to the slackened ventilation at the end of the week, which allowed the gas that had before been pressed back into and dislodged from the goaf, to fill up the space from which it had been dislodged by the stronger ventilation. That led him to think that it might be dangerous to increase the ventilation at a time like that, because it would insinuate itself into the goaf, and bring out a larger quantity of gas than was ordinarily given off.

Mr. GREENWELL said the question was as to how it was to be accounted for that, in a very low state of the barometer, that gas disappeared into the goaf, and in a higher state of the barometer it appeared at the edge of the goaf, because it was so contrary to what we heard, or read, or knew of.

Mr. WILD read the paragraph from his paper bearing upon this point:—"Influxes of gas arise in several ways ——, &c." He said it all hinged upon the ventilation, on the extra firing, causing a partial vacuum.

The CHAIRMAN: Yes; I think Mr. Greenwell has left that out of consideration for the present. He wants you to explain how a falling barometer would compress gas into the goaf, rather than, as is generally found, expand it and allow of its coming out.

Mr. WILD said he thought he must have been rather misunderstood.

Mr. GREENWELL: That is the way I understood Mr. Wild to have stated it: that, in a very low state of the barometer the gas which, in a higher state of the barometer had appeared at the goaf edge now, in this low state of the barometer disappeared from the goaf edge.

Mr. WILD said there must have been a misunderstanding. The high state of the barometer had not been mentioned. The reason why he sent the man down on the Sunday morning was because there was a great depression in the barometer,

and he expected that a greater quantity of gas would be given off; but when the man got to the place he found there was none. It would not show at all. This occurred several times, both in the 2ft. and in the old mine.

Mr. GREENWELL said the only way—if they did not misunderstand Mr. Wild—of accounting for it is simply this: that there were accumulations of gas, under certain circumstances, in the higher part of the goaf, and that—rejecting for the sake of argument the question of the barometer—on an increase of the ventilation, such as Mr. Wild described, on the air coming through the goaf down to that point, the increased ventilation sent through the goaf brought that gas down, which in a less active state of the ventilation continued further in the goaves.

The CHAIRMAN: Yes; it would be impossible for Mr. Wild to maintain that point—that a falling barometer caused the gas to recede in the goaf. It is opposed to all the ordinary laws of physics. It is quite possible—I do not at all doubt it—that they found the gas so receding; but it must have been due to some other cause than a falling barometer.

In reply to a question by Mr. J. BURROWS,

Mr. WILD gave some further explanation with the aid of the diagram, and afterwards said that they were agreed upon the question of the barometer. He had not stated in the paper that it was through any depression that the gas fell back, but through the weakened ventilation. It might be said that during the depression a stronger ventilation should be kept up, but in working homewards the ventilation might insinuate itself further into the goaf left behind, and sweep out a large quantity of gas into the return airway. He thought, according to special rule 11, it would be an infringement to dislodge gas suddenly.

The CHAIRMAN quoted from the report of the previous

discussion some remarks made by Mr. Bryham, observing to Mr. Wild that it was the increased ventilation that was challenged—whether that would bring about an increase of gas in larger proportion than the increase of ventilation.

Mr. WILD said he thought they must all admit that an increase in the ventilation would have the effect of sweeping gas out of the goaves; and if the gas was swept out, there were only the return air-ways for it to mix in. If men were at work on the return side, they ought to be warned, and the ventilation should not be increased until they were warned and got out of the way. That was the view he took of a sudden increase.

Mr. WILD said, in answer to Mr. Bryham's observation at the previous meeting—namely, that he had never known such a case as that mentioned by him (Mr. Wild)—cases where too much air rendered a mine dangerous were very well known. In re-opening a mine, after an explosion, it was sometimes deemed advisable not to increase the air too suddenly, but to let it pass into the mine gradually. He thought, in a particular case mentioned by the Chairman, it was slackened purposely, to render it more safe—as it was often dangerous; while barrels of water were being poured down to increase the quantity of air, the operation had to be suspended on account of the danger arising therefrom.

The CHAIRMAN: That was because of its producing sudden gusts with fire-damp that might fire through the Davy.

Mr. GREENWELL said there was only one possible case where a larger quantity of air might be attended with bad results—that was in the case of a sudden blower of gas. No doubt if a large quantity of gas was liberated, and they had a very active current of air—not sufficient to render the gas inexplosive as it came off, but producing with it an explosive mixture that would be felt hundreds of yards distant—in such a case they might have a much more

extensive explosion than there would be if they had a smaller quantity of air. That was the only case he could bring forward where an excessive quantity of gas would be dangerous.

The CHAIRMAN: Where it was not sufficient in quantity to dilute the gas given off.

Mr. WILD, in reference to another point in his paper, which was challenged at the previous meeting, namely, the practicability of a separating valve, said he should be very glad to hear the opinion of gentlemen better acquainted than he was with the subject as to the possible force of an explosion. He added, by way of practical illustration, if we take a good sized colliery, with a workable area of 1000 yards square, or say about 200 statute acres, the case in point being a heavy explosion arising from the ignition of fire-damp. Space filled with explosive gas contains say 1000 cubic feet of light carburetted hydrogen and 9000 cubic feet of atmospheric air thoroughly mixed. This mixture would occupy a roadway of 400 yards in length, the sectional area of which = 25 square feet, or a cavity of 100 feet long × 20 feet broad × 5 feet high; a receptacle capacious enough to contain the elements necessary for a large explosion. By ignition say we get a tenfold expansion in the space of five seconds, thus we have a volume equal to 100,000 cubic feet moved through an airway of 25 feet sectional area in five seconds, giving a velocity equal to 4000 feet in the above space of time, or 800 feet in one second. Then, as 100 feet per second gives a force of about 24lbs. per square foot, by increasing the velocity eightfold and squaring that, we get a pressure of about 1536lbs. per square foot, or about 10lbs. per square inch. I think it would be easy to make a valve or crossings that would stand that.

Mr. GRIMSHAW said the cry now was "air," and plenty of

it would do everything as far as safety was concerned. But if they looked into the matter, it would be found that the more air there was, in certain circumstances, if an explosion took place, and the more extensive and the more disastrous was the result of that explosion. He did not believe it was altogether a question of air. Under certain conditions when there was a great quantity of air the explosion was more disastrous than it would have been were there a less quantity of air. He did not think they were altogether on the right track as regarded ventilation; at all events recent occurrences had shown that they were not entirely. He never found a single instance in all his reading of where those extra doors, or valves, had withstood the effects of an explosion of any magnitude.

Mr. WILD: Whether those doors were made of iron or not is not stated.

Mr. GRIMSHAW: There was one at the Hepburn Colliery; the air crossing was made of boiler plate.

Mr. WILD: It may have been only a very small one. We had an explosion which blew down the flue inside the furnace archway; it bent the doors. The crossings were all right, and the men worked through the crossings in the brow. There were twelve of them did not know even that an explosion had occurred. The tubes were all right, and the flat sheet crossing as well.

Mr. J. BURROWS said it ought not to go forth as the opinion of the meeting that large quantities of air, in coal mines, could be done without. He did not see how a high velocity could be avoided in sending a large quantity of air, say 1200 yards.

Mr. GRIMSHAW said the question was—is not it safer to use a less quantity in certain places at certain times?

Mr. SEDDON said that his experience led him to believe that no crossings could be constructed which would withstand

the force of some of the recent explosions. On the occasion of the inquiry succeeding the unfortunate Pemberton explosion, Mr. Armstrong gave some evidence as to its force. His (Mr. Armstrong's) theory appeared to be that some of the men were compressed to death.

Mr. WOODWARD said his opinion was that nothing they could put up would resist the violence of some of the explosions which had lately occurred. From what he had seen, he doubted whether any iron doors, or any iron air-crossings, would be sufficient for the purpose. They saw enormously strong masses of brickwork entirely swept away —disintegrated, as it were; not one brick being left attached to another—and that being so, he believed swing doors, mounted on woodwork, or a framework of any kind, would stand very little chance; still there was no reason why they should not be tried. There was another point on which he would make an observation, that was with regard to ventilation. He did not think they should let it go forth that it was advisable to have a small quantity of ventilation, because that, he thought, would be going against all the teachings of the present time, and all the experience of the present time, which was that in every colliery they should have a sweeping ventilation. He believed, himself, that it was one of the great points of safety to have a good sweeping ventilation. Of course an outburst of gas might occur which would overcome any ventilation that could possibly, perhaps, be established, and an explosion resulting from it might be much more violent when that large quantity of gas was rapidly diluted and spread through the workings by means of a large volume of air; but he thought it ought not to go forth that it was a good thing to have a reduced quantity of air in any case. He thought in all cases—not alone looking at the fact of explosions, but having regard also to the health of the men and of the animals which had to work in

pits—it was advisable to have good ventilation. Something had been said with regard to pressure. There was no doubt that in some violent explosions which had occurred lately many deaths had been owing to the enormous pressure. On reading up latterly some little on this subject, he found that gas, at its most explosive point, expanded to about 4337 times its own volume. That showed what a poor chance a man would have of life in an atmosphere expanded at that enormous velocity.

The CHAIRMAN said that the observations he made, when Mr. Wild read his paper, expressed really all that he had to say upon the subject. He considered the proper laying out of a mine to be the most important matter of all. Large quantities of air were of little use if a mine was badly laid out. He saw it stated in some of the measurements taken at Abercarne, that there were 600 or 700 cubic feet of fire damp per minute coming off; and at the Oaks he believed there were 500 cubic feet. There must be large quantities of air to dilute such issues of gas as those.

Mr. GRIMSHAW, referring to Mr. Woodward's observation, said that it was hardly a question of lessening the ventilation. The ventilation used in all collieries, at least as far as he knew them, was much better than it had ever been before; but there was such a thing—and in considering the matter it had to be seen plainly that there was such a thing—as having too much air in this way. Of course, if they had more air they would manage to go through matters safely, but if they were just on the borderland—not the borderland between safety and danger—but supposing something unexpected were to happen, when that thing did happen the disaster was a great deal worse than it would have been if there had been less air.

Mr. WOODWARD said the law required that, in colleries, the ventilation must be "sufficient to dilute and render harmless noxious gases."

Mr. GREENWELL said that one point had not yet been touched upon in the discussion, namely, as to the explosive character, falsely so called, of coal dust, but really coal dust distilled into gases by the heat of explosions, and thereby adding to the violence of explosions. He wished to connect that, at the present moment, with what had been said as to the probable effects of what might be called violent ventilation. It seemed to be probable, or at any rate possible, that violent ventilation, in the case of a very dusty pit, might cause a larger quantity of that dust to intermingle with the atmosphere than would be the case with a smaller quantity of ventilation; they might have, owing to the presence of the coal dust, a larger addition to the violence of the explosion than might be the case with a smaller quantity of air. It was clear that the more violent the air the greater would be the admixture of that fine inpalpable dust with it as it travelled through the mine.

The CHAIRMAN said that in dusty mines, where the floor would admit of its being done, watering cans should be used; and as far as possible the drawing roads should be on the intake, so that the dust might be swept into the workings and deposited in the old goaves as the coal was drawn back.

Mr. GRIMSHAW: They water some of the mines at Barnsley regularly.

The CHAIRMAN: Some mines are covered a couple of inches deep with pure dust, particularly where the drawing roads are in the return airway.

Mr. GREENWELL: I think all the gentlemen present will agree with this, that it is desirable to have the drawing roads in the intake air; and I should say that it would be a very questionable piece of management, generally speaking, to have a colliery with the drawing roads in the return air instead of in the fresh air.

The discussion was then brought to a close.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XV. SESSION 1878-9.

An ORDINARY MEETING of the Members of the Society was held on Tuesday, the 25th February, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

Mr. W. H. Warburton, Colliery Manager, Norbury Colliery, near Stockport; Mr. John Greenwood, junr., Ashton Moss Colliery, Audenshaw, near Manchester, were elected ordinary members of the Society; and Mr. George Henry Kinahan, M.R.I.A., of H.M. Geological Survey, Ireland, was elected an honorary member.

BLASTING BY MEANS OF COMPRESSED AIR.

BY Mr. W. E. GARFORTH.

In endeavouring to dispense with the use of gunpowder and other explosives in mines some chemical compounds and a great number of mechanical appliances have been tried with more or less success. In many cases letters patent have been taken out for breaking down coal by hydraulic apparatus, and by wedges of peculiar construction. The first patent taken out to use highly compressed air was by

Mr. Macnab, of South Wales, and this was followed, some time afterwards, by Mr. Marsh's patent. These gentlemen, therefore, may be said to be the originators of the compressed air cartridge principle.

As my intention is to lay before you the result of experiments with compressed air at a pressure of 8000lbs. and upwards per square inch, I will endeavour to explain the principle as briefly as possible.

About two years ago a machine was invented which can now be worked by two men. It is portable, and of dimensions suitable for even small mines, and by means of it air has been compressed to 946 atmospheres, or 14,200lbs. per square inch. After the air is compressed it is conveyed through wrought iron pipes to a cast iron cartridge, say 11¼ inches long, which is placed in a hole drilled in the coal, from 30 to 40 inches deep, and when the breaking strain of the cartridge (which is ascertained beforehand) is reached, it bursts and breaks down the coal. No doubt there are many members present who have air compressing engines working at 40lbs. or 60lbs. pressure per square inch, for the purpose of driving underground hauling and pumping engines, who will admit that in trying to compress air to 70lbs. or 80lbs. pressure per square inch they have experienced many disappointments, owing to the air valves proving defective, loss of air through "churning," and the exhaust passages getting blocked with ice and snow. Considering these difficulties it will readily be understood the trouble that has been experienced in obtaining a pressure of 14,200lbs. per square inch.

Although I should like to enter into a full account of the construction of the machine, and of the manner in which this enormous pressure is obtained, also as to the theory of the vaporized state of highly compressed air, yet, as this detailed information would occupy too much

time, and a view and examination of the machine would be a simpler method of enabling you to understand its construction, I propose in this paper to simply inform you that the rams or plungers of the machine are comparatively a loose fit, the valves are as simple as the commonest pump clack or bucket (and can be changed in two or three minutes time), and all the parts are extremely simple in construction and not liable to derangement. With regard to the form and strength of the pipes and cartridge several obstacles had to be overcome. In the first instance the cartridges were made by Mr. Marsh of tin, afterwards of cast iron—the latter were, however, very imperfect in construction, varying in thickness as much as $\frac{3}{16}$ of an inch, and altogether unreliable. This was one of the reasons—though not the principal one—why the experiments Mr. Marsh conducted at Wigan were so unsuccessful. The cartridges are now made by means of a machine, and are so perfect and regular that by adding $\frac{1}{32}$ of an inch to the internal diameter the bursting pressure can be ascertained to ·25 per cent. between one cartridge and another, and this uniformity has many times been proved by actual experiment.

At my suggestion, and by the kind permission of Mr. Rothwell, the machine was, some months ago, taken down one of the collieries at Denton. The first attempt to break down coal was a failure, owing to the cartridge not being a tight fit in the hole, which had been made by a common drill in the ordinary way, and instead of the bursting cartridge producing an immediate and sudden effect on the coal it was gradual, and simply resulted in the air around the cartridge being compressed.

I have had the experiments which were made by Mr. Marsh at Wigan fully described to me, and considering the important alterations which have since been made, among others, in driving the machine (which now only requires one

half the power it formerly did); the improvements in the cartridges, but especially as regards the hole being properly drilled, I can easily understand that without these vital improvements the experiments at Wigan could not be less than a failure. After the first experiment at Denton I suggested to Mr. Reuss that the hole in the coal should be drilled by a small machine, and made so true that the cartridge would fit it tightly, so that if possible not a unit of force should be lost. Without describing the numerous visits which Mr. E. Reuss and I have made down the pit to perfect this drilling machine, nor the principle that coal can be chipped much easier than ground, I may state that by constant thought on Mr. Reuss' part, the drilling machine is now so perfect that it can be easily fixed ready for drilling without props and at any angle, also that it has often bored a hole in the coal six inches in depth in two minutes time.

After several months experimenting with the drilling machine another trial was made to burst down the coal, and was so far successful as to warrant the construction of an entirely new machine, capable of compressing air to 1323 atmospheres, or 20,000lbs. pressure on the square inch,—one that would remedy the many defects of Mr. Marsh's old machine, which had been found, during the experiments, weak in most of the working parts,—and, in having only four rams, the turning was irregular, and the supply of air intermittent. This new machine has been made by Messrs. Garforth, of Dukinfield, and has already compressed air to 14,200lbs. per square inch, or 946 atmospheres, and is capable, I fully believe, of giving 20,000lbs. pressure per square inch. It is neither so high, so long as the first machine, being only 4ft. 5in. long, 3ft. 4in. high, and 20 inches wide, and weighing 8cwts. 2qrs. 7lbs., including draw bar, handles, and all accessories. It can be adapted to any guage on an ordinary colliery tramway.

By the kind permission of Messrs. Marland, of Hollinwood, and Mr. Smith their manager, a trial was made at Bower Colliery, in the presence of some members of this Society, under the following conditions:—

The coal is known as the Bower Mine; it is 5 feet thick, and of a very hard nature; it was undercut to a depth of 4ft. 6in., and by the drilling machine a perfectly true hole was cut 39½in. in depth, and 7ft. from the cut end of the coal. The cast iron cartridge 11¾in. long, 3 1/16in. diameter, 1/16in. thick, was then put in this hole, and stemmed tight, the pipes and machine were next attached, and at 9550lbs., or 636 atmospheres, pressure per square inch the coal was broken down. The quantity was estimated at between 5 and 6 tons.

Having now described to you some of the difficulties which have been experienced in perfecting the cartridge, the air compressing, and drilling machines, and also the effect of 9550lbs. pressure on the coal, I will endeavour to place before you my ideas of how this power can be utilised.

I must first state that among other points the following have been proved:—

(a.) That 14,200lbs. has been (and I venture to think 20,000lbs. pressure per square inch may be), obtained.

(b.) That a pressure of 9550lbs. has been proved to be sufficient to break down the coal in a hard mine like that at Bower Colliery.

(c.) When the air at these great pressures is obtained, it can be kept for hours both in the machine pipes and cartridges.

In making the following suggestion as to how this power may be utilised, I think a machine to meet the requirements of deep mining should be one that would not require much manual labour, owing to the high temperature consequent on deep and extensive workings.

What I propose is to use a vessel or small receiver made so very strong that the bursting point will be six or seven times the required pressure,—one proved beyond doubt to be perfectly safe in transit, also of such a capacity as will allow the highly compressed air to expand into the pipes and cartridges without reducing the pressure below the known bursting point of such cartridge. The air compressing machine necessary to fill this receiver with highly compressed air may be fixed on the surface, or, if preferred, at the bottom of the shaft, and worked by steam or compressed air at 40lbs. pressure per square inch in the ordinary way. These portable receivers should then be charged with air of the required pressure, sent into the various working places, attached by means of a special valve and pipes to the cartridge placed in the coal, and then by simply opening such valve the air in the receiver would rush into and explode the cartridge, at the same time breaking down the coal without requiring much manual labour. Of course it will be understood that the receiver can either be placed at a safe distance, or to obviate the use of pipes, it can be placed near to the face of the coal, and the valve opened by other means.

If the expansion of the air necessitated a larger receiver, a small hydraulic pump could be connected to it, and by forcing water through a valve opening upwards, the water would then occupy the space of the air, and by this means any pressure which had been lost through expansion could be recovered, and if necessary increased. As water is comparatively speaking incompressible, the time taken to effect this operation would not be long, nor the labour very great and the same water could be used over and over again. This arrangement is the one which I think will be eventually adopted.

In the same way in which machines are altered

and the original idea improved upon, I feel convinced that in a short time this great force of 10,000, 15,000, or 20,000lbs. pressure per square inch will be so utilised that we shall be able to put into the hands of the miner a power which, if gunpowder and other explosives are prohibited, will enable him to get coal with the same facilities as now, but above all without loss of life from blown out shots and explosions, and without the production of deleterious gases, which so seriously affect the ventilation of any mine.

It may appear strange to old miners to propose to place small machines in the hands of each workman, but certainly not more so than it did to engineers when men chipped or worked by hand what is now done by planeing, riveting, or other machines. When we consider the restrictions at present placed upon the use of gunpowder and other explosives in mines, and that every day the coal to be gotten lies at a greater depth, and the difficulties in getting increase more than *pro rata* with such depth, I think there can be little doubt that in a few years Government will either entirely prohibit or place more stringent restrictions on the use of gunpowder.

I now propose to compare the system of breaking down coal by means of gunpowder with that of compressed air at 8000lbs. pressure or upwards per square inch.

The undermining of the coal will in both cases be about the same, also the time taken to drill the hole, provided the machine drill is used.

If the arrangement of receiver, as proposed in the foregoing remarks, be carried out, then the time taken to fire the gunpowder or burst the cartridge by compressed air will likewise be about the same.

In stemming the hole there will be a gain in favour of gunpowder of about ten minutes, but at a much greater risk.

If, instead of the portable receiver the machine had to compress the air to the required pressure, then there is a gain of 25 to 35 minutes in favour of gunpowder; but, as we are all aware, after an explosion of gunpowder, the working place, if not well ventilated, is so filled with powder smoke for a quarter, half, or even three-quarters of an hour, that the advantage gained in the time is quite counterbalanced.

Compressed air, however, possesses advantages over gunpowder, as regards its safety, which cannot be too highly estimated.

I think everyone connected with mining will admit that the time has now arrived for some power to be found to supply the place of gunpowder if it be prohibited, to enable us to get coal as economically in the future as now.

Should gunpowder and other explosives be prohibited, what *is* the next best means of supplying their place? I think, for the reasons I have stated, that compressed air will stand foremost as a substitute, more especially on account of its safety, and although monetary considerations may to a certain extent weigh with some people, yet no one can for a moment deny, after seeing the lavish expenditure made by colliery proprietors for the safety of their men, that *safety* is the main consideration both of mine owners and their managers.

Mr. JOHN HIGSON said he should be glad to know if Mr. Garforth could give the meeting any idea of what increased cost would be placed upon the working of coal, by the adoption of compressed air. It would also be interesting to know what were the probabilities of risk, through the bursting of the cartridges, when handled, in and about the working of the machine.

Mr. G. WILD said he had the pleasure of witnessing the experiments that were conducted the previous evening, at the Bower Colliery, and he must say that, so far as the

throwing down of the coal was concerned, the effect of compressed air seemed quite equal to that of gunpowder. The coal was not very much broken, but it was broken sufficiently to split up for filling. The time occupied certainly was long; and looking at the matter in all its bearings, he thought much would need to be done before the apparatus could supplant gunpowder, where gunpowder was admissible. As a scientific experiment, however, it seemed to him to be quite a success. The enormous pressure that was obtained, and the time that elapsed before the explosion of the cartridge, seemed to come in very well with previous calculations. The cartridge burst at a pressure of 9550 lbs., and the calculation had been from 9000 lbs. to 10,000 lbs. Altogether, it seemed to him to be a good start, and might be the forerunner of something that would supersede gunpowder. The blasting of the cartridge was somewhat like the bursting of a shell. The cartridge, he should say, broke into a score of pieces, and the whole of the pieces lay just below the hole. The coal is thrown down just as a shot would have thrown it down. He (Mr. Wild) asked Mr. Smith, the manager of the colliery, how a shot would have been, as compared with that; and he said that it would be about the same, except that the lumps were rather larger, but it was quite as clean as a shot.

Mr. Grimshaw said that he also was present at the experiments at the Bower Colliery. The delay in the firing of the cartridges were mainly owing to some small defects, which would have to be, and could be, overcome in the compressing machine. The cartridge was about half-an-inch thick, and 11¾in. by 2in. or so, inside, and the time taken up in exploding the shell—for it was nothing more than that—when the machine was got into order, was about nine minutes. There was very little slack made. The coal was not much blown, but it was blown down, not in large lumps

—(he supposed that would be on account of the cleavages), but in lumps that would be readily split and filled into round coal. He had not the slightest doubt, after seeing the experiment, and after going into the place immediately after the shot had been fired, that the little failures that existed in the machine would be overcome, simply because, in any experiment of that sort, it was the details that interfered with success; and they have to be, and in this case no doubt will be, overcome one by one. At a previous experiment, the cartridge was so completely shattered that he counted 35 pieces; but the ends, being about 1½in. thick as against the half-inch of the body, remained intact. The pipe also, connected with the cartridge, through which the air was compressed, remained intact, and could be unscrewed from the end of the cartridge. There seemed to be a kind of Scotch mist created by the explosion, and at Bower Colliery (the place in which the last experiment was made), though cool before, was very much cooler after the blast.

Mr. PENMAN said that he was present at the first trials with compressed air, made at Wigan last year, and a difficulty then seemed to be the large escape of air between the machine and the shell. He did not gather from the paper, how the connection is made by Mr. Garforth.

Mr. HALL said it was no doubt very important that something should be introduced in place of gunpowder. Wedges in large numbers had been tried, and he thought he had tested most of them personally. Hydraulic driven wedges seemed to fail because the action was slow, and the others failed because the manual labour was too great. In the use of compressed air (and he said this not to discourage Mr. Garforth but rather to give him assistance) there were two or three weak points. First, he seemed to think that 9000lb. pressure would be sufficient to bring down hard coal. It was a mistake to assume any pressure less than

that exerted by gunpowder, for bringing down hard coal, and that was at least four times 9000lb. per square inch. With reference to carrying a vessel containing compressed air into the workings and transferring the pressure from that into the vessel already in the coal, his opinion was that, in that operation an immense amount of the pressure would be lost, because the air must, in that case, be expanded into twice the original space. Thus at least half the pressure would disappear. This would be a very great drawback. He believed also it would be found that there was great difficulty in preventing injury to the pipe through which the air passed by the falling coal. There was another point which he (Mr. Hall) advanced with great diffidence; it seemed to him a question whether it was possible to have any sudden expansion of gasses—air, if they liked—approaching anything like gunpowder in force without producing flames. He might be wrong in that; he just mentioned it so that it might be taken into consideration.

Mr. Woodward said the one difficulty that presented itself to his mind was, that in applying Mr. Garforth's suggestions to a large colliery, where they had a large number of working places, the cost would be a most serious consideration. Gunpowder was very cheap and very portable, and the question was how would the use of compressed air compare with it as to cost? Moreover, upon the system described by Mr. Garforth (of course it might be capable of improvement), he did not think they got anything like the pressure of the commonest gunpowder that was used. Then there was the question of portability and the difficulty of pipes. He had had something to do with compressed air, and at the present time was using it for a good many purposes; and the difficulty he found was the great costliness of the pipes for conveying the compressed air either to drills or any machine whatever for which they might be using it.

Even at the low pressure of 160lb. they found an indiarubber pipe lined with copper wire, a very expensive commodity; and it was of importance in such a matter to reduce, as far as possible, the expense. Then there was the point mentioned by Mr. Grimshaw. He said that after the explosion of the cartridge a sort of Scotch mist was perceptible. The question was—what effect would that mist have upon the roofs of some mines, because dampness in many mines was the cause of considerable displacements and falls of roof. Of course, if anything could be applied in the place of gunpowder, they ought to do everything in their power to bring it into use. Gunpowder, there was no doubt, was a source of danger, but then, as to compressed air, there came the question of applying it. Could an ordinary collier be trusted to apply that power in his working place? That, to his mind, was a most important consideration. In an ordinary colliery there would be, perhaps, 100 colliers, all using gunpowder. How long would it take to bring those colliers to apply compressed air instead, or safe to leave it in their hands under great pressures? Those were one or two points which presented themselves to his mind as matters of difficulty. Of course, if it came to be adopted, men would, no doubt, be educated up to the use of it.

Mr. RADCLIFFE said he had seen the experiments described, and was of opinion, from the effects of the blast, that compressed air did its work in a manner quite equal to or better than powder would have done it. It did not scatter the coal, and he could have stood within a couple of yards with perfect impunity. He took up some of the fragments of the shell immediately below the hole in which it had rested prior to the explosion. With reference to the supposed loss of pressure, he was of opinion that it would be extremely small. The pressure could be maintained even after having to fill the pipes and the cartridge. The pipes

did not need to be long. The air vessel could be placed a few feet from the cartridge, and the valve turned by other means than the hand. The blast had, undoubtedly, a cooling effect upon the working place, but he perceived no smoke or vapour. That was an important point in some collieries, where a large quantity of gunpowder was now used.

Mr. G. WILD said that, as Mr. Grimshaw had already remarked, the place felt quite cool after the explosion. He went into it directly after, but perceived none of the mist which Mr. Grimshaw said was noticeable in the boiler.

Mr. MARTIN said that one evening last week, at Mr. Garforth's works, he saw a cartridge exploded under a comparatively low pressure (7500lb.), and was surprised at the small size of the fragments. He did not think it at all likely that flame would be generated by the explosion. In the trial at Bower Colliery which was referred to, the coal was undoubtedly very strong, but it was holed, he thought, beyond the average distance. The danger of carrying the loaded shells about, he considered an important point.

The CHAIRMAN: Did you notice the mist?

Mr. MARTIN, Yes! but not particularly.

Mr. GRIMSHAW said there was a very distinct mist in the first experiment. There was a good air going into the mine at the time of the experiment on Monday evening, but there was a distinctly damp feeling in entering the place immediately after the cartridge had exploded.

Mr. HOLLINGWORTH said the mist, he thought, would be the result of coolness, owing to the expansion of the air. He would like to know if the shock arising from the blast would not be liable to explode the vessel containing the compressed air.

The CHAIRMAN said that was the risk. The study of explosives seemed to have been hitherto chiefly directed in

Mr. Macnab, of South Wales, and this was followed, some time afterwards, by Mr. Marsh's patent. These gentlemen, therefore, may be said to be the originators of the compressed air cartridge principle.

As my intention is to lay before you the result of experiments with compressed air at a pressure of 8000lbs. and upwards per square inch, I will endeavour to explain the principle as briefly as possible.

About two years ago a machine was invented which can now be worked by two men. It is portable, and of dimensions suitable for even small mines, and by means of it air has been compressed to 946 atmospheres, or 14,200lbs. per square inch. After the air is compressed it is conveyed through wrought iron pipes to a cast iron cartridge, say 11¼ inches long, which is placed in a hole drilled in the coal, from 30 to 40 inches deep, and when the breaking strain of the cartridge (which is ascertained beforehand) is reached, it bursts and breaks down the coal. No doubt there are many members present who have air compressing engines working at 40lbs. or 60lbs. pressure per square inch, for the purpose of driving underground hauling and pumping engines, who will admit that in trying to compress air to 70lbs. or 80lbs. pressure per square inch they have experienced many disappointments, owing to the air valves proving defective, loss of air through "churning," and the exhaust passages getting blocked with ice and snow. Considering these difficulties it will readily be understood the trouble that has been experienced in obtaining a pressure of 14,200lbs. per square inch.

Although I should like to enter into a full account of the construction of the machine, and of the manner in which this enormous pressure is obtained, also as to the theory of the vaporized state of highly compressed air, yet, as this detailed information would occupy too much

time, and a view and examination of the machine would be a simpler method of enabling you to understand its construction, I propose in this paper to simply inform you that the rams or plungers of the machine are comparatively a loose fit, the valves are as simple as the commonest pump clack or bucket (and can be changed in two or three minutes time), and all the parts are extremely simple in construction and not liable to derangement. With regard to the form and strength of the pipes and cartridge several obstacles had to be overcome. In the first instance the cartridges were made by Mr. Marsh of tin, afterwards of cast iron—the latter were, however, very imperfect in construction, varying in thickness as much as $\frac{3}{16}$ of an inch, and altogether unreliable. This was one of the reasons—though not the principal one—why the experiments Mr. Marsh conducted at Wigan were so unsuccessful. The cartridges are now made by means of a machine, and are so perfect and regular that by adding $\frac{1}{32}$ of an inch to the internal diameter the bursting pressure can be ascertained to ·25 per cent. between one cartridge and another, and this uniformity has many times been proved by actual experiment.

At my suggestion, and by the kind permission of Mr. Rothwell, the machine was, some months ago, taken down one of the collieries at Denton. The first attempt to break down coal was a failure, owing to the cartridge not being a tight fit in the hole, which had been made by a common drill in the ordinary way, and instead of the bursting cartridge producing an immediate and sudden effect on the coal it was gradual, and simply resulted in the air around the cartridge being compressed.

I have had the experiments which were made by Mr. Marsh at Wigan fully described to me, and considering the important alterations which have since been made, among others, in driving the machine (which now only requires one

half the power it formerly did); the improvements in the cartridges, but especially as regards the hole being properly drilled, I can easily understand that without these vital improvements the experiments at Wigan could not be less than a failure. After the first experiment at Denton I suggested to Mr. Reuss that the hole in the coal should be drilled by a small machine, and made so true that the cartridge would fit it tightly, so that if possible not a unit of force should be lost. Without describing the numerous visits which Mr. E. Reuss and I have made down the pit to perfect this drilling machine, nor the principle that coal can be chipped much easier than ground, I may state that by constant thought on Mr. Reuss' part, the drilling machine is now so perfect that it can be easily fixed ready for drilling without props and at any angle, also that it has often bored a hole in the coal six inches in depth in two minutes time.

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Having now described to you some of the difficulties which have been experienced in perfecting the cartridge, the air compressing, and drilling machines, and also the effect of 9550lbs. pressure on the coal, I will endeavour to place before you my ideas of how this power can be utilised.

I must first state that among other points the following have been proved:—

(a.) That 14,200lbs. has been (and I venture to think 20,000lbs. pressure per square inch may be), obtained.

(b.) That a pressure of 9550lbs. has been proved to be sufficient to break down the coal in a hard mine like that at Bower Colliery.

(c.) When the air at these great pressures is obtained, it can be kept for hours both in the machine pipes and cartridges.

In making the following suggestion as to how this power may be utilised, I think a machine to meet the requirements of deep mining should be one that would not require much manual labour, owing to the high temperature consequent on deep and extensive workings.

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If the expansion of the air necessitated a larger receiver, a small hydraulic pump could be connected to it, and by forcing water through a valve opening upwards, the water would then occupy the space of the air, and by this means any pressure which had been lost through expansion could be recovered, and if necessary increased. As water is comparatively speaking incompressible, the time taken to effect this operation would not be long, nor the labour very great and the same water could be used over and over again. This arrangement is the one which I think will be eventually adopted.

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and the original idea improved upon, I feel convinced that in a short time this great force of 10,000, 15,000, or 20,000lbs. pressure per square inch will be so utilised that we shall be able to put into the hands of the miner a power which, if gunpowder and other explosives are prohibited, will enable him to get coal with the same facilities as now, but above all without loss of life from blown out shots and explosions, and without the production of deleterious gases, which so seriously affect the ventilation of any mine.

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Mr. JOHN HIGSON said he should be glad to know if Mr. Garforth could give the meeting any idea of what increased cost would be placed upon the working of coal, by the adoption of compressed air. It would also be interesting to know what were the probabilities of risk, through the bursting of the cartridges, when handled, in and about the working of the machine.

Mr. G. WILD said he had the pleasure of witnessing the experiments that were conducted the previous evening, at the Bower Colliery, and he must say that, so far as the

throwing down of the coal was concerned, the effect of compressed air seemed quite equal to that of gunpowder. The coal was not very much broken, but it was broken sufficiently to split up for filling. The time occupied certainly was long; and looking at the matter in all its bearings, he thought much would need to be done before the apparatus could supplant gunpowder, where gunpowder was admissible. As a scientific experiment, however, it seemed to him to be quite a success. The enormous pressure that was obtained, and the time that elapsed before the explosion of the cartridge, seemed to come in very well with previous calculations. The cartridge burst at a pressure of 9550 lbs., and the calculation had been from 9000 lbs. to 10,000 lbs. Altogether, it seemed to him to be a good start, and might be the forerunner of something that would supersede gunpowder. The blasting of the cartridge was somewhat like the bursting of a shell. The cartridge, he should say, broke into a score of pieces, and the whole of the pieces lay just below the hole. The coal is thrown down just as a shot would have thrown it down. He (Mr. Wild) asked Mr. Smith, the manager of the colliery, how a shot would have been, as compared with that; and he said that it would be about the same, except that the lumps were rather larger, but it was quite as clean as a shot.

Mr. GRIMSHAW said that he also was present at the experiments at the Bower Colliery. The delay in the firing of the cartridges were mainly owing to some small defects, which would have to be, and could be, overcome in the compressing machine. The cartridge was about half-an-inch thick, and 11¾in. by 2in. or so, inside, and the time taken up in exploding the shell—for it was nothing more than that—when the machine was got into order, was about nine minutes. There was very little slack made. The coal was not much blown, but it was blown down, not in large lumps

—(he supposed that would be on account of the cleavages), but in lumps that would be readily split and filled into round coal. He had not the slightest doubt, after seeing the experiment, and after going into the place immediately after the shot had been fired, that the little failures that existed in the machine would be overcome, simply because, in any experiment of that sort, it was the details that interfered with success; and they have to be, and in this case no doubt will be, overcome one by one. At a previous experiment, the cartridge was so completely shattered that he counted 35 pieces; but the ends, being about 1½in. thick as against the half-inch of the body, remained intact. The pipe also, connected with the cartridge, through which the air was compressed, remained intact, and could be unscrewed from the end of the cartridge. There seemed to be a kind of Scotch mist created by the explosion, and at Bower Colliery (the place in which the last experiment was made), though cool before, was very much cooler after the blast.

Mr. PENMAN said that he was present at the first trials with compressed air, made at Wigan last year, and a difficulty then seemed to be the large escape of air between the machine and the shell. He did not gather from the paper, how the connection is made by Mr. Garforth.

Mr. HALL said it was no doubt very important that something should be introduced in place of gunpowder. Wedges in large numbers had been tried, and he thought he had tested most of them personally. Hydraulic driven wedges seemed to fail because the action was slow, and the others failed because the manual labour was too great. In the use of compressed air (and he said this not to discourage Mr. Garforth but rather to give him assistance) there were two or three weak points. First, he seemed to think that 9000lb. pressure would be sufficient to bring down hard coal. It was a mistake to assume any pressure less than

that exerted by gunpowder, for bringing down hard coal, and that was at least four times 9000lb. per square inch. With reference to carrying a vessel containing compressed air into the workings and transferring the pressure from that into the vessel already in the coal, his opinion was that, in that operation an immense amount of the pressure would be lost, because the air must, in that case, be expanded into twice the original space. Thus at least half the pressure would disappear. This would be a very great drawback. He believed also it would be found that there was great difficulty in preventing injury to the pipe through which the air passed by the falling coal. There was another point which he (Mr. Hall) advanced with great diffidence; it seemed to him a question whether it was possible to have any sudden expansion of gasses—air, if they liked—approaching anything like gunpowder in force without producing flames. He might be wrong in that; he just mentioned it so that it might be taken into consideration.

Mr. Woodward said the one difficulty that presented itself to his mind was, that in applying Mr. Garforth's suggestions to a large colliery, where they had a large number of working places, the cost would be a most serious consideration. Gunpowder was very cheap and very portable, and the question was how would the use of compressed air compare with it as to cost? Moreover, upon the system described by Mr. Garforth (of course it might be capable of improvement), he did not think they got anything like the pressure of the commonest gunpowder that was used. Then there was the question of portability and the difficulty of pipes. He had had something to do with compressed air, and at the present time was using it for a good many purposes; and the difficulty he found was the great costliness of the pipes for conveying the compressed air either to drills or any machine whatever for which they might be using it.

Even at the low pressure of 160lb. they found an indiarubber pipe lined with copper wire, a very expensive commodity; and it was of importance in such a matter to reduce, as far as possible, the expense. Then there was the point mentioned by Mr. Grimshaw. He said that after the explosion of the cartridge a sort of Scotch mist was perceptible. The question was—what effect would that mist have upon the roofs of some mines, because dampness in many mines was the cause of considerable displacements and falls of roof. Of course, if anything could be applied in the place of gunpowder, they ought to do everything in their power to bring it into use. Gunpowder, there was no doubt, was a source of danger, but then, as to compressed air, there came the question of applying it. Could an ordinary collier be trusted to apply that power in his working place? That, to his mind, was a most important consideration. In an ordinary colliery there would be, perhaps, 100 colliers, all using gunpowder. How long would it take to bring those colliers to apply compressed air instead, or safe to leave it in their hands under great pressures? Those were one or two points which presented themselves to his mind as matters of difficulty. Of course, if it came to be adopted, men would, no doubt, be educated up to the use of it.

Mr. RADCLIFFE said he had seen the experiments described, and was of opinion, from the effects of the blast, that compressed air did its work in a manner quite equal to or better than powder would have done it. It did not scatter the coal, and he could have stood within a couple of yards with perfect impunity. He took up some of the fragments of the shell immediately below the hole in which it had rested prior to the explosion. With reference to the supposed loss of pressure, he was of opinion that it would be extremely small. The pressure could be maintained even after having to fill the pipes and the cartridge. The pipes

did not need to be long. The air vessel could be placed a few feet from the cartridge, and the valve turned by other means than the hand. The blast had, undoubtedly, a cooling effect upon the working place, but he perceived no smoke or vapour. That was an important point in some collieries, where a large quantity of gunpowder was now used.

Mr. G. WILD said that, as Mr. Grimshaw had already remarked, the place felt quite cool after the explosion. He went into it directly after, but perceived none of the mist which Mr. Grimshaw said was noticeable in the boiler.

Mr. MARTIN said that one evening last week, at Mr. Garforth's works, he saw a cartridge exploded under a comparatively low pressure (7500lb.), and was surprised at the small size of the fragments. He did not think it at all likely that flame would be generated by the explosion. In the trial at Bower Colliery which was referred to, the coal was undoubtedly very strong, but it was holed, he thought, beyond the average distance. The danger of carrying the loaded shells about, he considered an important point.

The CHAIRMAN: Did you notice the mist?

Mr. MARTIN, Yes! but not particularly.

Mr. GRIMSHAW said there was a very distinct mist in the first experiment. There was a good air going into the mine at the time of the experiment on Monday evening, but there was a distinctly damp feeling in entering the place immediately after the cartridge had exploded.

Mr. HOLLINGWORTH said the mist, he thought, would be the result of coolness, owing to the expansion of the air. He would like to know if the shock arising from the blast would not be liable to explode the vessel containing the compressed air.

The CHAIRMAN said that was the risk. The study of explosives seemed to have been hitherto chiefly directed in

relation to purposes of war, but the large gathering of practical mining engineers, managers, and agents who were then present, showed that, in their opinion, it also had its attractions in regard to purposes of mining. It is, perhaps, of more importance in relation to the economy of labour and the cheap production of material or work that explosives were of importance to the miner, for it was only by the saving of labour and cheap production that the sinews of war could be provided. But, like most useful inventions, they were not all good, and all that should be expected of them was that they should have a balance of advantage in their favour. They knew that powder in the working of some mines was at the present time indispensable: but if the day should come, which Mr. Garforth prophesied, when its use would be entirely prohibited, still the need of some explosive, be it compressed air or water, would be indispensable unless they reverted to the times depicted in a book which would be found in the library, having three or four centuries back, when the rocks had to be softened with fire, and the miners had to protect themselves as best they could from suffocation. There were others besides Mr. Garforth who were seriously of opinion that the day would come when gunpowder would be prohibited in mines. He had not himself, however, been able to look at it in that light. He thought, with the aid of such precautions as presented themselves to practical men, powder might continue to be used until some explosive was found that would be attended with fewer drawbacks. The drawbacks to this invention had been named. The chief ones were extra cost and the risk of carrying the compressed air about the mine. These were points which Mr. Garforth had taken notes of, and might be able to answer. The mist perceived after explosion had, he thought, been satisfactorily explained by the sudden appropriation of the latent heat

from the surrounding atmosphere, which, as the paper described, produced ice; so that to that extent if the compressed air were carried into the mine in portable vessels and there exploded it would have a cooling effect in deep mines, which was very important. Then doubts had been expressed as to sufficient pressure being obtainable in any way comparable to the pressure of gunpowder.

Mr. REUSS said that the gentlemen who had already spoken were for the most part mining engineers. His business, however, had only been to make a machine which would effect a given purpose. In the Wigan experiments the cartridges used were made of tin or cast iron, and the internal bore being uncertain it was impossible to say at what pressure they would explode; therefore his first consideration was to make a cartridge that would go off at a certain pressure. To do this a peculiar machine for casting had to be prepared, so that $\frac{1}{32}$ of an inch could be added to the internal bore, each $\frac{1}{32}$ inch, so added, giving an additional pressure of 1000lbs. This pressure was further increased when the cartridge was put into the rock; for instance a cartridge that went off in the presence of Mr. Martin the other day at 7500lbs.—if that had been put into the coal experimented on the previous day (Monday) a pressure of 1500lbs. more would have been needed to make it explode. The cartridge used at the Bower Colliery went off at a pressure of 9500 lbs. and he was informed by Mr. Grimshaw that the effect upon the coal was the same as if two blasts of powder had taken place with 1½lb. of powder. One of the previous speakers had made a comparison of the bore exerted by powder and compressed air. The action of gunpowder upon coal was rather to smash it, whilst that of compressed air was as if a lever were used to wedge it down from the roof or sides as the case might be. It had been remarked that, in former

experiments, the joints of the machine did not hold; the cause of that was the suddenness and irregularity of the different injections of air. In the machine they now had in use, and which might be seen by any gentlemen interested in the matter, the action was continuous—there were no jumps.

The CHAIRMAN asked how the pressure is ascertained.

Mr. REUSS said there are two pressure guages, one to check the other.

Mr. JOHN HIGSON asked if the breaking point of the cartridge would be dependent upon the nature of the strata in which it was inserted—assuming the hole to be drilled by machinery, so that a perfect fit might be obtained.

Mr. REUSS said that it took a greater pressure to blast the same cartridge at the Bower Colliery than it would have done at Denton, where the coal is not so strong.

Mr. GARFORTH said he did not know whether Mr. Higson was aware, that all the experiments hitherto had been conducted to ascertain what pressure could be obtained. But he had endeavoured to show that, as compared with under-cutting, the difference in time taken between compressed air and gunpowder to break down the coal would be very trifling. The cost of the former, he admitted, was more than that of gunpowder; but against the cost they must put the additional safety, which was of the greatest importance. With respect to the supposed danger from the machine bursting, he might say the barrels were made of Whitworth's compressed steel, and therefore stronger than there was any real necessity for. When the air was forced through the valves, there was not the same danger of giving way or rebounding in the machine as might be imagined. Mr. Wild, while admitting the machine had done all that was required, stated that it was more of a scientific experiment, which he considered hardly a fair definition, as the results were eminently practical. In

answer to Mr. Hall, who had compared the force of gunpowder with that of compressed air, he might say the opinions of scientific men with respect to the force of gunpowder varied very considerably, from the time of Sir Humphrey Davy to that of Faraday, but Prof. Abel placed it at 42 tons to the square inch—that was, gunpowder of a certain quality—and assuming the power was present which had to be overcome. If, however, gunpowder be placed upon a plate and ignited, it explodes with a puff; but, if the same quantity were confined in a sufficiently strong and closed vessel, the pressure stated would be exerted. In the same way, colliers know that if they use eight ounces of gunpowder in certain mines, it breaks the coal into nearly all small; and, perhaps, five ounces would have done the work adequately, and produced a better result. With compressed air, it had been proved that with a hole 39½ inches deep, and a certain distance from the undercut, it required only a pressure of 9550lbs. per square inch to force the coal down with the advantage of giving a large proportion of best coal.

The CHAIRMAN: that will be about 4¾ tons per square inch as compared with 40 tons per square inch by gunpowder.

Mr. GARFORTH further said Mr. Hall had also doubted whether the pressure could be maintained. In reply he might say, that he had in experimenting at 6000 lbs. proved, that this pressure can be maintained for several hours, and when the construction of the valves was understood, he thought it would be admitted that there was nothing by which the pressure could be lost. The presence of mist, after the explosion, might be explained by the fact that a certain quantity of water was forced into the receiver with each stroke of the pump. The vapour was, as it were, held in mechanical suspension; and he argued that there was not sufficient heat in the place to hold it in suspension

for any length of time, as it was heavier than air, it must naturally fall to the ground. They had never found the roof of a mine in that clammy wet state, which it would be in if any large amount was given off. Mr. Grimshaw's remark, he thought, was not so much with regard to mist being given off in the mine, as to that which he perceived in the boiler when a cartridge was exploded, simply to show him what pressure could be got. There, it was confined in a very small space; and, consequently, all the more perceptible. In reply to Mr. Woodward, he thought his (Mr. Garforth's) idea could be carried out, and receivers made sufficiently strong to stand a test of seven or eight times, or even more, than the working pressure; then the miners, being assured of their safety, could be induced without much difficulty to use them.

Mr. MARTIN asked what the cost of the cartridge would be.

Mr. GARFORTH said he could not state the cost exactly. But by adopting a cheaper mode of fixing the pipes to the cartridge, and by having the latter made of steel, the cost would be considerably less than it was at present, and perhaps better results would be obtained.

NOTES ON SOME TRIASSIC BORINGS.

By C. E. DE RANCE, Assoc.M.Inst.C.E., F.G.S.

In 1835, Sir Roderick Murchison (Proc. G. S., Vol. II.) gave the following classification of the red rocks overlying the Coal Measures:—

1. Red and green marls. . . . . *Keuper.*
2. Sandstone and conglomerate. . *Bunter.*
3. Calcareous conglomerate . . . . *Zechstein.*
4. Lower red sandstone. . . . . *Roth-todt-liegende.*

In 1837, the Rev. Professor Buckland ascribed the Warwick sandstones, with their reptilian fauna, to the age of the Keuper of Germany, and compared them with the building stones of Stuttgard and Sinzheim, near Heidelberg. These Warwickshire sandstones consist of either soft, white, or grey sandstones, more or less thin-bedded and interstratified with marl, with a slightly conglomeratic base, resting indiscriminately on Permian or Coal Measures, and may be considered as the typical English "Waterstones."

In papers read before the British Association in 1842, and the Geological Society of London in 1846, and before this Society at a still earlier date, Mr. Binney was the first to give the chief outline of the classification of the Lancashire and Cheshire post-carboniferous red rocks, the sequence being:—

Trias (Murchison):—

1. *Red Marl* (Ormerod)	*(a)* Red and variegated marls		ft.
	(b) Gypsum and saliferous marls....	800	„
	(c) Waterstones	440	„
2. *Bunter Series*	.....Maximum thickness.....	600	„
Permian. 3.	Red and variegated marls and magnesian limestone	210	„
4.	Lower New Red Sandstone	120	„

In this classification I am inclined to think that the term "waterstones" does not include the compact Lower Keuper building stone and grit, which was evidently classified with the Bunter beds beneath in the papers by Mr. Ormerod and others of the period. This restricted use of the term "waterstones" is one which it is of importance to maintain, as probably it, and not the building stones beneath it, are the equivalent of the typical waterstones of Warwickshire.

In 1854, Professor Hull laid a paper before the British Association, showing the Bunter beds were capable of a triple sub-division—massive sandstone with pebbles, or pebble beds, intervening between an upper and a lower red and

mottled sandstone. Occasionally the Pebble beds are only soft sand with shingle, and the Mottled Sandstone beneath it gradually thins out eastward, its maximum development being in the Shropshire area. In later papers he pointed out that Lower-Keuper sandstone not only rests unconformably in an eroded surface of Bunter, but that the former in the Ashby-de-la-Zouche country passes directly over the latter, and was deposited entirely independent of it.

Borings made from time to time since this date have proved the steady overlap not only of the Keuper over the Bunter, but of the various sub-divisions over themselves; and as the journals of these borings have for the most part been communicated to the Underground Water Committee of the British Association, it may be useful to capitulate the information on the maximum thicknesses and gradual wedging out of strata they present to us.

Lancashire.—At Bootle, near Liverpool, an important boring has been carried to a depth of 1304 ft. by Messrs. Mather and Platt, for the Liverpool Corporation water supply. The diameter is 25 in. to a depth of 1000 ft., and 20 in. beneath that limit. The water-level stands at 50 ft. from the surface in the bore-hole, but has not yet been pumped. This level is about that at which water stood in the adjacent Bootle well, when not pumped some years ago. The character of the Pebble Beds is well seen in the quarry in which the old well is sunk, and in the large quarry higher up the hill, from which it is evident that the thickness of this division of the Bunter is not less than 1200ft., instead of 600 to 800, as anticipated; the base of the Pebble Beds occurring in the boring at 1039ft., where the Lower Mottled sandstone was first penetrated, the well-known "millet seed grain" being specially characteristic. This is well seen in the Lower Mottled sandstone of the Vale of Clywd.

The Lower Mottled sandstone in the Bootle boring becomes very hard and compact at 1228ft. from the surface, being cemented together by lime; but the grain, when the rock is broken up, is seen to be the same. For details of this boring and for facilities to inspect the cores I have to thank Messrs. Mather and Platt, of Salford Iron Works.

For similar facilities I have to thank Mr. Beck, of Dallam Lane Forge, Warrington, for a boring made at that place. From an inspection of the cores, in company with my colleague, Mr. Strahan, we constructed the following journal:—

			feet.	
	1.	Boulder clay and drift	30	Upper mottled bunter.
	2.	Red and pale yellow, soft rock..	350	
	3.	Red and white ditto, slickensides	2	
600 feet.	4.	Flaggy micaceous sandstone .. / Red sandstone & thin shale bands / Micaceous flags and slickensides	218	
	5.	Red and white Sandstone	159	
752 „		FAULT.		
	6.	Red Sandstone with pebble....	58	Pebbles beds.
887 „	7.	Soft Red Sandstone	70	Lower mottled Sandstone.

At a depth of 227 feet from surface 40 grains of salt per gal.

„	345	„	„	170	„	„
„	390	„	„	300	„	„
„	445	„	„	750	„	„
„	500	„	„	1246	„	„
„	600	„	„	1575	„	„
„	680	„	„	3100	„	„
„	756	„	„	4000	„	„
„	818	„	„	4500	„	„

These figures represent number of grains per gallon pro-

duced, by nitrate of silver, *i.e.*, chlorides alone, the water has a strong briny taste

From this section it will be noticed that we are of opinion that no less than 752 feet of Upper Mottled sandstone is proved by the boring without the base being reached, the Pebble Beds beneath being thrown in by the fault, which possibly acts as a duct for the salt water.

Midland Counties.—In Lancashire, the "Waterstones" of Messrs. Binney and Ormerod pass insensibly into the overlying Keuper marl, there being no sharp line of demarcation. In Staffordshire, Leicestershire, and Warwickshire this is also the case, except around Charnwood Forest, where the red marls overlap the Waterstones, and rest directly on the palæozoics. This is also the case in the Bristol Channel, both in Somersetshire, Gloucestershire, and South Wales, the Waterstones coming in for the first time to the north-east of the Forest of Dean, east of Mitcheldean and Newent. If a line be drawn from Nottingham, south-west to Worcester, it will mark the easterly thinning of the Bunter deposits. The Waterstones extend further, being present at the boring through the oolites of Burford (previously published by me), being deposited against an old palæozoic ridge, which was overtopped by the Keuper marls above, which sweep round the Mendips, the *local* "Dolomitic Conglomerate" being generally present where the underlying rock is the Carboniferous Limestone.

Of the Bunter deposits, the Lower Mottled sandstone is the first to disappear eastward, the Pebble Beds resting directly on the Permian on both sides of the South Staffordshire coalfield, and on the carboniferous rocks of Dovedale. In the latter district the Lower Keuper sandstone rests directly on the Pebble Beds. Northwards, from Nottingham to Selby, this is also the case, the Upper Mottled being entirely absent, and the Lower Mottled maintaining a well-

marked thickness. Still further north, at Middlesbro', the Pebble Beds have probably thinned out, and the Keuper rests on the Lower Mottled sandstone.

In Lancashire and Cheshire, below the soft, fine-grained sandstones and shales, or Keuper waterstones, occur massive building stones, with soft beds traversed by current bedding on the top, between which and the overlying evenly-bedded Waterstones there is a well-marked junction. The line of boundary going eastwards is seen to gradually overlap the older rocks, the Lower Keuper building stones being reduced to a few feet at Nottingham, and being entirely absent in Warwickshire and the greater part of Leicestershire. These remarks will explain the true Waterstones resting in some of the following sections on the palæozoic rocks. The sections were collected by Mr. James Plant, F.G.S., of Leicester, for the Underground Water Committee.

Hawkesbury Pumping Station, Coventry (Mr. Sinclair) 252 feet above O.D.L. :—

Drift	30	feet	
Waterstones	90	„	(White sandstone.)
	120	„	

Holywell Boring, Hinckley Local Board (+ 330 O.D.L.):—

Drift (clay and gravel) ..	150	feet	
Red Marl.....	20	„	
Waterstones	370	„	(Shale, gypsum, and sandstone.)
	540	„	

Elmsthorpe, Leicestershire (+ 300 O.D.L.) :—

Drift	10	feet
Red Marl	120	„
Waterstones	330	„
Coal Measures	980	„
	1440	„

Linridge Hall Colliery Boring, Desford (+ 400 O.D.L.) :—

Drift	2 feet
Upper Keuper Sandstone	20 „
Red Marl and Gypsum..	44 „
Waterstones	204 „
	270 „

Near Desford, close to 9 milestone on Leicester railway:—

Marl	213 feet
Waterstones	140 „
	350 „ to Slate.

Austy Paper Mill, near Leicester (+ 225 O.D.L.) :—

Drift (boulder, clay)....	70 feet
Red Marl and Gypsum..	117 „
	187 „

Hathern, Leicestershire—north of Charnwood Forest (+ 320 O.D.L.) :—

Drift	10 feet
Red Marl	110 „
Waterstone	140 „
*Conglomerate (Lower K.S.)	60 „
	320 „

Chilwell Boring, Leicestershire (+ 450 O.D.L.) :—

	Ft.	In.	
Drift	13	8	
Upper Keuper Sandstone ..	53	0	
Red Marl	53	4	
Waterstones	115	0	
Soft Sandstone.....	110	4	
Conglomerate	30	8	
Lower Mottled Sandstone ..	44	4	
.....	15	5	
	435	9	Carried to 1036 ft.

* These Conglomerates are well seen at Castle Donnington.

The eastern boundary of the outcrop of the Pebble Beds of the Bunter ranges along the River Trent, past Nottingham, as far as Stanston and Swarkeston. Eastward of this line, the Keuper Sandstone rests on the Coal Measures of Ashby-de-la-Zouch, and the Carboniferous Limestone of Breedon Hill.

Ranging parallel to this line and eastward of it, the Lower Keuper sandstone, building stones and conglomerate, thin out, being last met with at Hathern, ranging north of Charnwood and Atherstone. South of Nuneaton, fine grained white sandstone, used for building occurs, interbedded with evenly bedded shale of the Waterstones.

North of the Trent, the Lower Keuper sandstone conglomerate is reduced to 5 or 6 feet, resting on the Pebble Bed, lying on thin beds of Lower Mottled sandstone, which again comes in here, being absent in the area adjoining the Lancashire and Staffordshire coalfields, east of the Cheshire Red Marl plain.

At Owthorpe, south-east of Nottingham, a boring was carried to a depth of 1147 ft. 10 in., and a 2 ft. 4 in. coal being reached at 1145 ft. 6 in.

North Yorkshire and Durham.—Through the kindness of Mr. H. H. Howell, of H.M. Geological Survey, I have been able to examine the six-inch maps of the district around Middlesboro, in Durham and Yorkshire, on which the position of the various deep borings are marked, as well as the natural exposures of rock. At Hunworth, and near Low Diresdale, current bedded red and yellow flaggy sandstone at 10° to the northward. This dip is, however, probably local, as further eastward good sections of these sandstones occur in the banks of the river Tees in the direction of Stockton, dipping S.E., which is also the dip of the magnesian limestone of Aycliffe, and that of the overlying rhœtic beds of Yorkshire. This dip evidently obtains in the

Middlesboro' salt area, as the salt deposit was met with at a shallower level at Messrs. Bells boring, north of that of Messrs. Bolckow & Vaughans. Still further north there is a local roll on the coast near Greatham, close to which there is a boring, 1½ miles W. of Seaton Carew, 529 feet deep.

A bore-hole was put down in 1828 by Mr. Fletcher, at Oughton, about a mile north of Greatham, and two west of Seaton Carew. Details given by Mr. Peacock, C.E., Trans, Cleveland, L. and P. Soc., 1870 :—

		Depth.	Thickness.
			Ft. In.
Drift.	1. Soil		1 0
	2. Gravel, with water		11 0
	3. Blue clay, very strong		27 0
	4. Sand, with a little water		1 8
	5. Blue clay, very strong		8 6
	6. Red sand		3 6
	7. Sandy clay		5 2
	8. Red sand		8 2
	9. Blue clay		3 10
	10. Sandy clay		1 6
	11. Sand, with a little water		0 8
	12. Clay, very strong, pebbles		24 0
	13. Grey freestone		2 0
	14. Grey sand		4 2
	15. Clay, very strong		1 9
	16. Clay brown, very fair	136 0	9 1
	17. Brown freestone		5 0
	18. Grey metal		7 5
	19. Brown post, with girdles		3 0
	20. Red stone		12 7
	21. White post, very strong, metal partings		5 4
	22. Grey metal		1 2

	Depth.	Thickness.
		Ft. In.
23. Red freestone		4 1
24. White post		3 2
25. Red freestone		15 0
26. Post girdles		0 9
27. Red freestone		22 10
28. Blue metal		3 6
29. Red freestone		11 6
30. Blue metal		2 0
31. Red freestone, post		6 0
32. White post girdles		0 6
33. Blue metal		1 6
34. Red freestone, post		13 0
35. White post girdles		0 6
36. Red freestone, post		8 6
37. White post		6 0
38. Red metal		12 0
39. White post girdles		0 6
40. Red freestone, post		6 0
41. White post		0 6
42. Red freestone, post		17 2
43. Whin girdles		0 4
44. Red freestone, post		17 2
45. Strong whin girdles		0 2
46. Red metal		2 0
47. Strong whin girdles		0 8
48. Red metal		3 0
49. Strong brown post, with metal partings		4 0
50. Red metal		6 0
51. Grey metal		3 2
52. Red freestone, post		17 6
53. Red bastard whin		0 10

	Depth.	Thickness.
		Ft. In.
54. Red metal.....		0 2
55. Strong whin girdles.....		0 8
56. Red metal.....		9 0
57. White post girdles		0 4
58. Red metal.....		13 8
59. White post girdles		0 2
60. Red metal and white		6 2
61. Red metal.....		1 6
62. White post girdles		0 8
63. White stone, resembling spar..		0 4
64. Red metal.....		0 4
65. Bastard whin girdles		0 6
66. Red metal.....		0 2
67. Bastard whin girdles		0 5
68. Soft red freestone, metal partings		3 6
69. Red metal.....		1 6
70. Red freestone, post		2 7
71. Red metal.....		0 4
72. Brown freestone, post		15 8
73. Red metal.....		0 8
74. White post		1 1
75. Red metal.....		0 6
76. Brown freestone, post.....		6 6
77. Red metal.....		0 6
78. White post		2 0
79. Red metal.....		0 4
80. Brown freestone, post.....		2 0
81. Red metal, very strong		1 0
81. ,, ,, soft		1 2
82. Brown freestone, post.....		3 10
83. Red metal.....		0 8
84. Brown freestone, post.....		3 4

		Depth.	Thickness.	
			Ft.	In.
85.	Red metal, strong		1	6
86.	„ „		0	6
88.	Strong brown post, with feeder			
89.	of water		3	0
89.	White post girdles		0	2
90.	Red metal.....		1	0
91.	White post girdles		0	10
92.	Red metal, with post girdles ..		14	4
93.	Strong brown post		3	0
94.	Red metal.....	329 9	0	4
95.	Coal.....		0	4
96.	Red metal.....		1	0
97.	„ strong		6	0
98.	Strong freestone, post.....		6	6
99.	Soft red metal		0	3
100.	Brown whin.....		1	2
101.	„ freestone		0	10
102.	„ whin.....		5	4
103.	„ freestone		0	7
104.	„ whin.....		5	7
105.	White stone, resembling spar..		0	3
106.	Brown freestone		2	9
107.	„ whin		2	6
108.	Strong white post.....		4	0
109.	„ whin post		1	1
110.	White whin		0	1
111.	Strong white stone		3	11
112.	„ grey post		1	6
113.	„ blue post		0	6
114.	Blue metal		1	3
115.	Brown stone.....	517 9	6	7
			517	9

Boring at old Brewery, Norton Street, of Stockton. Geological Survey Sheet 50 Durham :—

	fm.	ft.	in.
Made ground	0	1	2
Black sand	0	4	10
Light-coloured sand	0	2	10
Loamy clay	5	2	6
Brown strong clay	1	0	6
Dark sand	1	4	0
Brown strong clay	3	2	4
Sand, with water	0	3	0
Clay, with stone	2	0	0
Yellow freestone	0	2	6
Rough gravel under	0	1	6
Hard red sandstone	4	1	0
Red sand and mould	2	3	6
Soft red metal	1	0	0
Hard red sandstone	5	5	6
Soft red metal	1	4	6
Hard red shale	1	5	4
	33	2	2

I have to thank Mr. Allison, of Guisboro', for the Section of Strata bored through by the Diamond Drill Co., at Salthouse Farm, on the Durham side of the Tees, for Messrs. Bell Bros., 15th December, 1874 :—

No.	STRATA.		Thickness. Ft.	in.	Depth. Ft.	in.
1.	Soil	Drift 77·0.	1	6	1	6
2.	Clay		4	0	5	6
3.	Dark sand		7	6	13	0
4.	Clean sand		26	0	39	0
5.	Red clay		3	0	42	0
6.	Sand and gravel		8	0	50	0
7.	Boulder clay		27	0	77	0

No.	STRATA.	Thickness Ft.	in.	Depth. Ft.	in.
8.	Red marl	73	0	150	0
9.	Red sandstone, with veins of marl.	144	0	294	0
10.	White sandstone	1	3	295	3
11.	Red sandstone, with veins of marl	153	9	449	0
12.	Red sandstone	10	0	459	0
13.	Soft marl	3	0	462	0
14.	Red sandstone	6	0	468	0
15.	Blue vein	0	10	468	10
16.	Red sandstone	31	2	500	0
17.	Red sandstone, with veins of marl.	27	0	527	0
18.	Soft marl.	4	0	531	0
19.	Red sandstone	29	0	560	0
20.	Red sandstone, with veins of marl.	49	0	609	0
21.	Soft marl	6	0	615	0
22.	Red sandstone, with veins of marl.	31	0	646	0
23.	Red sandstone	6	0	652	0
24.	Marl, with blue veins and sandstone	17	0	669	0
25.	Red sandstone, with veins of marl.	66	0	735	0
26.	Blue vein	0	7	735	7
27.	Red sandstone, with veins of marl.	13	5	749	0
28.	Strong marl	9	6	758	6
29.	Red sandstone, do.	26	6	785	0
30.	Blue vein	0	3	785	3
31.	Strong marl	6	3	791	6
32.	Red sandstone, with veins of marl.	30	6	822	0
33.	Strong marl and sandstone	17	0	839	0
34.	Red sandstone, do.	16	0	855	0
35.	Strong marl	20	0	875	0
36.	Red sand and marl	5	0	880	0
37.	Red sandstone do.	14	0	894	0
38.	Strong marl, veins of sandstone	6	0	900	0
39.	Strong marl	23	0	923	0

No.	STRATA.	Thickness Ft.	in.	Depth. Ft.	in.
40.	Strong marl with veins of gypsum ..	7	0	930	0
41.	Mixed marl and sandstone	27	0	957	0
42.	Marly sandstone, with veins of gypsum	141	0	1098	0
43.	Gypsum..	4	0	1102	0
44.	Hard white stone	3	9	1105	9
45.	Gypsum...	3	6	1109	3
46.	Marly sandstone, very salt	1	1	1117	4
47.	Decayed red marl, with salt	10	3	1127	7*
48.	*Red rock salt*	9	0	1136	7*
49.	*Rock salt*	66	5	1203	0
50.	Salt, with marl and gypsum	19	0	1222	0
51.	Gypsum containing salt	7	0	1229	0
52.	Soft shale, with salt and gypsum ..	7	0	1236	0
53.	Soft white shale	2	0	1238	0
54.	Gypsum and antrydrite	23	0	1261	0
55.	*Magnesian limestone* (liberation of gas)	52	0	1313	0
56.	Grey limestone..	15	0	1328	0
57.	Gypsum....	8	0	1336	0
58.	Gypsum, containing salt	1	0	1337	0
59.	*Rock salt*	14	0	1351	0
60.	Marl containing salt....	2	0	1353	0
61.	Marl with gypsum	1	0	1354	0
62.	*Impure salt*	1	0	1355	0

* 40-45 per cent. of Salt, only 3 feet core, fresh water being used.

Section by Mr. John Marley, C.E. (Brit. Assoc., 1863), of Strata Sunk and Bored through at Middlesbro, for Messrs. Bolckow Vaughan & Co. Began 4th July, 1859. Diameter of borehole 1ft. 6in. Boring ceased 29th August, 1863. Messrs. Mather and Platt's process :—

No.	STRATA.	Thickness Ft.	Thickness in.	Depth Ft.	Depth in.
1.	Made ground, (Slag chalk, &c.)	11	0	11	0
2.	Dry slime or river mud	8	0	19	0
3.	Sand with water	10	0	29	0
4.	Hard clay (dry)	10	0	39	0
5.	Red sand with a little water	1	0	40	0
6.	Loamy sand with a little water	3	0	43	0
7.	Hard clay (dry)	15	0	58	0
8.	Rock, mixed with clay and water ..	11	0	69	0
9.	„ „ (dry)	1	0	70	0
10.	„ „ gypsum (dry)	6	0	76	0
11.	Gypsum with water	2	0	78	0
12.	Red sandstone with small veins of gypsum	55	0	133	0
13.	Gypsum rock (dry)	6	0	139	0
14.	Brown shale with water	1	0	140	0
15.	Red sandstone	4	0	144	0
16.	„ „ with small veins of gypsum	12	0	156	0
17.	Blue sandstone with water at bottom..	3	0	159	0
18.	Red sandstone with water..	19	0	178	0*
19.	„ „ .... ft. in.	437	4	615	4†
20.	Red and white sandstone .. 673 5	1	6	616	10
21.	Red sandstone....	215	7	832	5
22.	„ „ and clay	1	0	833	5
23.	„ „	52	3	885	8
24.	„ „ and clay.....	9	0	894	8
25.	„ „	66	5	961	1
26.	Strong clay	2	9	963	10
27.	Red sandstone and clay	1	6	965	4
28.	„ „	27	5	982	9
29.	„ sandstone and clay	9	9	991	9
30.	„ „ with a vein of blue rock	49	4	1051	1
31.	Red and blue sandstone	1	5	1052	6
32.	„ sandstone....	6	0	1058	6
33.	„ „ and thin veins of gypsum	1	5	1059	11

No.	STRATA.	Thickness Ft.	Thickness in.	Depth Ft.	Depth in.
34.	Red sandstone and thin veins of gypsum	39	8	1099	7
35.	„ „ blue clay and gypsum ..	1	2	1100	9
36.	„ „ with veins of gypsum ..	87	3	1188	0
37.	Gypsum	3	2	1191	2
38.	White stone	0	8	1191	10
39.	Limestone	2	8	1194	6
40.	Blue rock	0	2	1194	8
41.	Blue clay	0	2	1194	10
42.	Hard blue and red rock	0	10	1195	8
43.	„ white stone	2	7	1198	3
44.	Dark red rock	1	2	1199	5
45.	„ „ rather salt	6	7	1206	0
46.	*Salt rock*, rather dark (1.)	12	7	1218	7
47.	„ very dark (2.)	4	1	1222	8
48.	„ very light (3.)	3	6	1226	2
49.	„ rather dark (4.)	27	4	1253	6
50.	„ very light (5.)	43	6	1297	0
51.	„ rather light (6.)	9	0	1306	0
52.	Limestone	1	0	1307	0‡
53.	Conglomerate	6	4	1313	4

* Bottom of Sinking Shaft 12 feet deep. † Commenced Borehole. ‡ This resembles limestone and contains a great quantity of salt.

The following analysis of No. 5 bed, was made by Mr. John Pattinson, of Newcastle-on-Tyne:—

	Per cent.
Chloride of Sodium	96·0
Sulphate of Lime	3·09
Sulphate of Magnesia....	0·08
Sulphate of Soda.....	0·10
Silica	0·06
Oxide of Iron	trace
Moisture	0·04
	100·00

A boring for coal was commenced in 1856, for Lord Falkland, in Kirklivington, and carried on in 1857 and 1858, under the superintendence of my friend Mr. P. S. Reid, M.E.:—

		ft.	in.	ft.	in.
1.	Reddish clay			27	0
	Fine sand....			7	0
	Course sand....			4	0
	Fine sand....			10	0
	Reddish clay	Drift.		51	0
	Yellow sandstone	109	2	0	8
	White sandstone, hard ..			0	9
	Sand and gravel			4	0
	White sandstone			1	6
10.	Sand and gravel			3	3
			109	2	
	Light bluish sandstone			119	10
	White sandstone, extra hard			0	11
	Light fire clay			1	5
14.	Light fake (Scotch for *shale*)			2	6
	Red sandstone, in one bed			204	3
16.	Red fake and "blae" (Scotch for sandstone)..			1	0
	„ sandstone, hard			1	1
	„ „ soft			18	0
	„ fake and blue			0	3
	Sandstone, extra hard.. ..			2	3
	Fake			7	3
	Sandstone, extra hard.. ..			2	6
	Fake..			7	8
	Sandstone	76	3	4	0
	Fake..			4	8
	Sandstone			2	1
	Fake and clay			2	8
	Sandstone			3	9
	Clay....			0	7
	Light red sandstone			1	9
	Red sandstone in bed.. ..			13	9
32.	„ „			3	0

		ft.	in.	ft.	in.
33.	Magnesium limestone			6	9
34.	Red shale			3	0
35.	„ shale and clay			8	8
36.	„ shale clay			9	5
37.	Magnesium limestone			6	8
38.	Shale and clay			2	3
39.	Magnesium limestones			1	6
40.	Red shale and clay			5	1
	Sandstone, hard			9	1
	„ in bed			4	9
	Light red sandstone, hard			4	0
	Red sandstone, extra hard			1	4
	„ „ and beds of shale			6	4½
	„ shale with bands of red sandstone			16	2½
47.	Grey pyritic sandstone			1	0
	Red shale with beds of hard red sandstone			24	3
49.	*Gypsum*, called "chalk and pipe clay," by men			0	9
	Red shaly sandstone			6	9
	„ sandstone with a shaly appearance			20	6
	Shaly sandstone and gypsum			20	0
	Sandstone, with carb. and sulph. of lime			17	6
54.	Ditto			6	0
55.	Ditto			14	6
				710	0

Mr. Reid is of opinion that the beds 33, 37, and 39 are *not* truly referable to the magnesium limestone; Mr. Morley, C.E., however, considered these beds to belong to that formation, and the lower part of the boring to be in the lower permian sandstone.

Still further west, two borings for coal were put down at Woodhead, near Great Smeaton, in 1789, by General Lambton, the one 396 feet deep, the other 444 feet.

The following section is given in the Geological Society's Transactions, Vol. IV.:—

WOODHEAD BORINGS, 1789.

				ft.	in.	ft.	in.
1.			Soil and brown clay...	24	9	4	0
2.			Dark strong clay, with white boulders			20	9
3.			Red metal stone with grey girdles			48	0
			Red stone with white girdles			31	3
			Grey and white stone			4	0
			Gypsum, with flinty lumps ...			7	0
			Blue whin, with sulphur water	116	6	1	6
			Strong white post, whin girdles			6	6
			Bastard whin...			12	0
10.	231	3	Strong white post, with whin girdles			36	6
11.			Blue grey metal stone with white scars			8	0
12.			Gypsum...			2	6
13.			Soft red stone			6	0
14.			Red and white post			19	0
15.			White post with red scars.....			18	0
16.			Red, white, and grey post, red partings			27	0
17.			Soft blue-grey metal..... ...			4	0
18.			Grey and white post...			33	0
19.			Strong blue-grey stone... ...			5	0
20.			Strong white and grey stone..			60	0
21.	189	4	Whin...			3	0
22.			Mixture, whin			9	0
23.			Strong white calcareous post and white girdles...			99	4
						445	4

The 190 feet of white sandstone in the boring has been referred by some to the millstone grit, but probably belongs to the waterstone, as suggested by Mr. Peacock. He stated the sulphur spring met with in the boring, used at Middleton Spa, was also found in a search for gypsum, in a boring at Ormesburg (Mr. Pennyman's lodge gates,) near Middlesborough, in 1851, a depth of 40 feet, the section being :—

	ft.	in.
Clay and sand	7	0
Red clay	14	0
Blue metal	3	0
Ironstone girdle	0	4
Blue metal, with sulphur water at 16 ft.	16	8
	41	0

Two miles north-west of the Woodhead boring at Eryholme, a boring was put down in 1809, by Mr. George Allan, M.P., of which the following account is given by Mr. Peacock :—

		ft.	in.	ft.	in.
Sand				12	0
Clay and cobble stones	Drift,			16	0
Quick sand..	34 ft.			2	0
Cobbles and sand		34	0	4	0
Red sand post (water)				60	0
Grey sand post				3	0
Ditto, rather hard clay following				121	0
Red soft sand post				3	0
Strong red post				300	0
Soft red post, not so red				12	0
Hard dark-red post				90	0
Clay and post				3	0
Red post				24	0
Flooring ..... Grey				1	0
Hard grey post beds.				12	0
				666	0

Coatham Boring, 1867, (communicated by Mr. Peacock, M.E.) :—

			Depth.		Thickness.	
			ft.	in.	ft.	in.
	1.	Clay	6	0	6	0
Lower Lias.	2.	Blue shale, with dagger band ...			39	0
	3.	Nodular band			1	6
	4.	Blue shale			1	8
	5.	Nodular band			2	0
	6.	Blue shale			6	4
	7.	Nodular band			1	6
	8.	Blue shale			21	0
	9.	Bastard post grey			5	0
	10.	Blue shale, with hard band			33	0
Rhœtic.	11.	Dark shale, with sulphuretted band	165	0	12	0
	12.	White and grey post, with water *(brine)*			9	0
	13.	Red and white mottled post, and blue and white			12	0
	14.	Dark blue metal, with whin girdles			19	0
	15.	White shale	223	0	18	0
Keuper Marl.	16.	Red marl, mixed with gypsum			74	0
	17.	Whin band...			0	2
	18.	Red marl	118	6	23	0
	19.	Whin band...			0	3
	20.	Red marl, strong			7	0
	21.	Gypsum			1	4
	22.	Red marl	341	6	0	9

Works for the manufacture of salt formerly existed at Tod Point, but Mr. Peacock states whether sea water or the brine spring from the sea was used, is doubtful. About 1856, a 6 feet shaft was sunk on the marsh near Coatham, by the late Mr. Slate, of Redcar, in a fruitless search for

coal, a strong brine was met with, to find which the above boring was put down to find, but the brine spring met with did not realize expectation.

This boring is valuable as showing the actual junction of the lias and marls with gypsum, which latter, as pointed out by Mr. Peacock, are 28 yards thick in the Middlesboro' boring. The limestones, thick salt beds, and gypsum in that boring, are probably referable to the Permian, the intervening beds of red sandstone, 673 feet, are probably referable to the Water Stones and Lower Mottled Bunter, the Upper Mottled and Pebble Beds having thinned out.

In conclusion, it would appear that a gradual overlap eastwards, takes place in all the triassic strata, along a north-east and south-west line, the more marked transgression being that at the base of the Keuper Waterstones, and at the base of the Pebble Beds of the Bunter. Lines of extensive erosion occuring at the base of the Keuper building stones and conglomerates, and on the base of the Pebble Beds of the Bunter. The great thickness of these triassic deposits in the north-west, is proved by these borings, and and their thinning out to the south-east, is established, and has an important bearing on the depth to concealed coalfields as well as on the water bearing capacity of the Triassic Sandstones.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XV. SESSION 1878-9.

An ORDINARY MEETING of the Members of the Society was held on Tuesday, the 25th March, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

E. W. BINNEY, Esq., F.R.S., Vice-President, in the Chair.

SAFETY LAMPS.

By Messrs. WILLIAM SMETHURST, F.G.S., and JAMES ASHWORTH, Mining Engineers.

The most important question a mining engineer of the present day has to decide, on the opening up or continuing the safe working of coal mines, is which safety lamp he ought to choose, out of the large number now invented, to ensure the greatest security for himself, his workmen, and the mines under his care, amidst the ever varying conditions met with in their working.

Hitherto this decision has been left entirely in the hands of the mining engineer, and the consequence is that he has generally chosen the safety lamp which his training has led him to consider the best.

It is singular that our Government should have allowed so much latitude in the lighting of mines giving off firedamp, when we consider the stringent regulations enforced by Acts of Parliament to protect persons working in such mines, and there can be little doubt that if this question had only received greater attention, we should not have had so many lives lost by explosions during the last few years.

Therefore, with the certain knowledge that the members of this Society will bring forward all the information they can to second the few observations we have to offer, we now introduce this subject.

Papers on Safety Lamps have been read before kindred societies, experiments have been made both by committees of mining institutes and privately by mining engineers, and in one instance by a Royal Commission specially appointed for the purpose by the Belgian Government, and yet in no instance except the latter have the experiments so made resulted in any practical good.

Only those lamps approved of by the Commission referred to, and made according to the proportions specified in the decree, are allowed to be used in Belgium in mines giving off firedamp.

And we may here express our hope that the Royal Commission just appointed by our own Government may, after full investigation, report in favour of a similar law, as the importance of having some additional compulsory regulations regarding the lighting of mines has been forced on the attention of everybody, and ought not to be delayed longer than is compatible with a very careful enquiry.

A few months ago the Council of the North of England Institute of Mining and Mechanical Engineers considered that this question required the immediate attention of our

Government, and with the view of obtaining the opinions of all the Mining Societies and Associations in this country, they sent out invitations asking for representatives to meet them on the 15th of February last. Some accepted, some did not; but it mattered little, as the Government took the country by surprise by appointing a Royal Commission early in February to fully investigate the whole of the points bearing on mining disasters, thus granting the request before it was actually made, and consequently causing the abandonment of the proposed movement.

Without entering into the history or cause of our making experiments on safety lamps, suffice it to say that they were commenced prior to the Haydock explosion last year, and received additional impetus from the fact that the only reason which could be assigned for the first lighting of the firedamp in that case was the passage of the flame through a Davy lamp gauze in a very ordinary velocity of the ventilating current. We do not doubt that such was the case, assisted by the fine coal dust with which the ventilating current would be charged during working hours.

At Brynn, where we have made experiments on safety lamps, and which are being continued by Mr. Smethurst, there is a most important item to assist in the successful and practical pursuit of such an investigation, viz., a good supply of pure firedamp from that most dangerous of Lancashire coal mines, the Wigan six or nine feet.

After proceeding with our experiments for some time, we had to admit that many of the researches we should wish to pursue, to render our tabulated tests anything like complete, would occupy more time than we could devote to them, and we consider the experiments made thus far are only preliminary ones. Had we not promised to bring the subject forward at this meeting, we should certainly have delayed doing so.

We found in conducting our experiments, that we must study the results obtained by other experimenters as far as possible, and in doing so we searched some of the standard mining works, and were surprised to see how meagre is the information given on safety lamps.

Our surprise in this point was increased when we found so long ago as the year 1816, a Dr. Peters questioning the safety of the Davy lamp, and it is also a curious fact that more persons having no experience of its use have questioned its safety, than those who have, and it would be hard to explain how it is that we have gone on working with this lamp for so many years in fancied security in spite of most definite warnings of its insecurity in a low velocity of the ventilating current.

Yet so much confidence has been placed in the Davy lamp, that in explosions after explosions, it has been the lamp looked for and preferred before all others.

In the first volume of the Transactions of the North of England Institute of Mining and Mechanical Engineers there is a paper on Safety Lamps, by the President, in which he gives details of some experiments made by him in May, and also by Mr. T. J. Taylor, in June, 1853, with Davy lamps placed on a revolving arm in an explosive atmosphere of firedamp and air, resulting in the passage of the flame through the gauze in a velocity of 13 feet per second. Probably the reports of the Committees of 1835, 1849, 1852, and the South Shields Committee, caused Mr. Wood to make the above experiments in 1853, for they all come to the conclusion "that the Davy lamp was absolutely "unsafe, and that no doubt can remain that it has been the "cause of some of the hitherto unaccountable accidents "which have occurred; also, that, where a proper degree of "ventilation does not exist in a mine, the Davy lamp, or "any modification of it, must be considered rather as a lure "to danger than as a perfect security."

Even at this date, the danger of coal dust in the ventilating current was recognised by Mr. Darlington, who said "that there are very numerous instances of accidents "which could only be attributed to dust flying off a hot "lamp in sparks, and thus creating an explosion."

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These experiments were followed, in the year 1876, by the report of the Belgian Commission before referred to, which made a very extended and careful series of experiments without going over the same ground as the North of England Institute—in fact, beginning, where the latter left off.

Again the result had a practical ending, as the Belgian Government adopted the suggestions of their Commission,

and made the use of the Mueseler lamp, of certain specified dimensions, compulsory throughout all mines giving off firedamp.

We are enabled to place before you a translation of the whole of the experiments; firstly, through the kindness of the Chief of the Belgian Mining Department; and, secondly, through the practical assistance of Mr. C. G. Jackson, of the Wigan Coal and Iron Company, who has taken a great interest in our tests.

Before stating the results of our own experiments we will shortly give a history of the safety lamp.

The first attempt to light a mine giving off firedamp by anything excepting a candle, or other open light, was by phosphorescent fish skins; secondly by the steel mill, which was only safe up to a certain point; and thirdly by Dr. E. M. Clanny's first safety lamp invented in 1813.

This lamp deserves particular notice, as it was the first lamp ever taken into an explosive atmosphere, viz., on November 20th, 1815, without accident; its safety consisting in the fact that the air necessary for the combustion of the flame was blown into the lamp through a stratum of water in the bottom of the lamp by a pair of small bellows, whilst the heated gases passed out through a recurved tube at the top.

Dr. Clanny then made another lamp, in which he introduced the steam of water generated in a small vessel at the top of the lamp, and heated by the flame. Both these lamps were too clumsy for the ordinary work of a coal mine, and required the constant attendance of a boy to work the bellows.

It was not until three years later that the lamps which are still in general use were designed by Sir H. Davy and Mr. Stephenson.

During the interval, Mr. Tennant had noticed in his "Researches on Flame" that burning gases would not pass

through tubes of a certain diameter; and this principle Sir H. Davy further applied by discovering that flame would not pass through a great many appertures, when their depth was equal to their diameter.

Sir H. Davy communicated his discovery to the Philosophical Society in 1816, in a paper entitled "An account of "an invention for giving light in explosive mixtures of "firedamp in coal mines by consuming the firedamp," and in January, 1817, a further paper on "Some new experi- "ments and observations on the combustion of gaseous "mixtures, with an account of a method of preserving a "continued light in mixtures of inflammable gases and air "without flame."

Mr. Stephenson in his invention applied the principle that burning gases would not pass through tubes of a certain diameter, as his original lamp consisted of a glass cylinder with a perforated metal cap, to allow the heated air to escape, and a series of perforations in the bottom to admit the air necessary for the combustion of the flame, and the whole being surrounded by a sheet iron covering, containing large round holes to allow the light to pass outwards.

In the Stephenson lamp of the present day, this sheet iron covering is replaced by gauze, which constitutes practically the only difference between the form of the lamp as originally constructed, and the one now in every-day use.

Dr. Clanny, not disheartened by the practical failure of his first two lamps, invented and constructed another in the present well known form.

If we were to describe the whole of the safety lamps which have been invented since the three already described were brought out, we should find that the general principles of all of them originate from the Davy, Stephenson, and Clanny types, with the addition of metallic tubes in some instances.

The number of lamps invented between 1852 and 1875 averages about six per annum; and great efforts have evidently been made to invent lamps with locks that cannot be tampered with, or if tampered with, will cause the extinction of the flame, and, also, to ensure the total extinction of the flame when firedamp explodes in the lamp.

Of *locked* safety lamps, the best known types are those with the screw lock, the padlock, Craig and Bidders' magnetic lock, the lead rivet, and Teale's protector lock.

Of the type of lamps which are *self-extinguishing* when the firedamp explodes in the lamp, the best known are the Stephenson and the Mueseler.

Of improvements to produce a *better and more brilliant light*, we may name the Mueseler, the Williamson, and all classes of lamps using colzaline oil; and we wish to observe in passing that firedamp can be more easily detected by lamps using this oil than by lamps using ordinary lamp oils, this effect being due to the clearness of the flame.

Of safety lamps of *improved construction*, the numbers are too numerous to make it worth while giving a list, but the following are in actual use: the Mueseler, the Bainbridge, the Williamson, and the Pelton. Most of the lamps unnamed, although safe, are either too complex in their construction, too heavy (for instance the electrical lamp) or have some great fault which their non-practical inventors could not realize.

Of safety lamps *for use by firemen* in making their daily inspections, no lamp has in this country yet replaced the Davy or the Stephenson (with a shorter glass cylinder than ordinary workman's lamp), although a smaller percentage of gas can be more readily detected by the Muessler than by any of the above-named lamps.

The continued use of the Davy and Stephenson lamps by firemen probably arises from the fact that they are more

adapted to the ordinary method of shot lighting than any other form of safety lamp.

A difficulty is here met with in the shot lighter, who must use a lamp so constructed that he can heat his wire in the flame, and still have as safe a lamp as any in the mine; his lamp being often put to more severe tests than any other, and if a blown out shot takes place it would be the first to receive the concussion, the increased velocity, dust, and heated atmosphere. So far as our experiments have gone, the best and safest lamp to be used by a shot lighter is one of the improved "Jack" Davy lamps, referred to in this paper.

When commencing our experiments, we decided to construct with wooden boards a model of a coal working, consisting of two levels, and a cut through of 12in. by 6in. section, and three drifts out of the top level 12in. by 12in., with a brattice up the centre, with glasses placed in the sides in various places, to enable us to observe the effect produced when an explosion occurred.

We placed a sound Davy lamp at the top end of the drift (No. 3) nearest the upcast, filled No. 2 drift with gas, and then charged the ventilating current, which had a velocity of 9ft. per second, with a certain amount of gas, and as soon as the gas showed in the lamp the brattice in No. 2 was altered to allow the gas stored up to be carried by the current on to the lamp, resulting quickly in a heavy explosion which did practically no damage in the drift where the lamp was, nor in No. 2 except to split the boards on the top and bottom, but No. 1 and the cut through were completely destroyed, although the wood was oak boardings of 1¼ in. thick. This experiment was repeated with exactly the same result, thus showing in an experimental way that the greatest damage is not necessarily caused at the seat of the explosion.

After this experience we used only the straight level with escape doors, to give the force of the explosion free exit.

The velocity of the air current was regulated and maintained by a steam jet, and in our later experiments registered by a Dickinson's aneomometer up to 11ft. per second, and by a Biram above 11ft.

In all our latest experiments, the Dickinson was constantly in the tube, and the velocities were accurately taken at the exact time the explosion occurred, and all variation in the velocities during the tests were also accurately registered.

The records of our earlier experiments are not so complete as we could have desired, in consequence of the breakage of the Dickinson anemometer.

The lamps we have experimented on so far are:—

Davy type.—Ordinary Davy, large and small Scotch lamps, improved Davy by Mr. Smethurst, Do. do. by Mr. Ashworth and Mr. Woolrych, Davy of small diameter of gauze by Mr. U. E. Dickinson, and "Jack" lamps.

Clanny type.—Large and small Clanny's, Mueseler's lamps by various makers, Williamson, Pelton, Bainbridge, Eloin, Gray, Glover, and Cail.

Stephenson type.—Ordinary Stephenson and Williamson. With the following results:—

An ordinary Davy, with the shield down, in a velocity of pure air of 20ft. per second, without gas, and the flame facing the current, went out in 45 seconds.

Do., with shield towards the current, went out in 4 seconds to 15 seconds.

Tests with velocity of 20ft. over 3 minutes of time:

Davy, with shield up, went out at once.

Clanny lamp, in the same velocity, went out in 3 minutes; light very flickering; not a working light.

Williamson, in the same velocity: light very flickering; not a working light; not out.

Ashworth and Woolrych's Davy: flickering light, but steadier than the others; not out.

Stephenson: light very flickering.

Small Mueseler: good working light, and steadier than the others.

Ashworth's large Mueseler: very steady light.

Tests with velocity of 38 ft. per second over space of 3 minutes.

Clanny: very little light; out in 1 minute 7 seconds.

Stephenson, with large flame: not a working light at all; not out.

Ashworth and Woolrych's Davy—Teale's oil: flame very flickering; not out.

Small Mueseler: light much reduced; not a working light; not out.

Ashworth's large Mueseler: steady working light.

Some details of the experiments are set forth on the next page.

It is singular that our Government should have allowed so much latitude in the lighting of mines giving off firedamp, when we consider the stringent regulations enforced by Acts of Parliament to protect persons working in such mines, and there can be little doubt that if this question had only received greater attention, we should not have had so many lives lost by explosions during the last few years.

Therefore, with the certain knowledge that the members of this Society will bring forward all the information they can to second the few observations we have to offer, we now introduce this subject.

Papers on Safety Lamps have been read before kindred societies, experiments have been made both by committees of mining institutes and privately by mining engineers, and in one instance by a Royal Commission specially appointed for the purpose by the Belgian Government, and yet in no instance except the latter have the experiments so made resulted in any practical good.

Only those lamps approved of by the Commission referred to, and made according to the proportions specified in the decree, are allowed to be used in Belgium in mines giving off firedamp.

And we may here express our hope that the Royal Commission just appointed by our own Government may, after full investigation, report in favour of a similar law, as the importance of having some additional compulsory regulations regarding the lighting of mines has been forced on the attention of everybody, and ought not to be delayed longer than is compatible with a very careful enquiry.

A few months ago the Council of the North of England Institute of Mining and Mechanical Engineers considered that this question required the immediate attention of our

Government, and with the view of obtaining the opinions of all the Mining Societies and Associations in this country, they sent out invitations asking for representatives to meet them on the 15th of February last. Some accepted, some did not; but it mattered little, as the Government took the country by surprise by appointing a Royal Commission early in February to fully investigate the whole of the points bearing on mining disasters, thus granting the request before it was actually made, and consequently causing the abandonment of the proposed movement.

Without entering into the history or cause of our making experiments on safety lamps, suffice it to say that they were commenced prior to the Haydock explosion last year, and received additional impetus from the fact that the only reason which could be assigned for the first lighting of the firedamp in that case was the passage of the flame through a Davy lamp gauze in a very ordinary velocity of the ventilating current. We do not doubt that such was the case, assisted by the fine coal dust with which the ventilating current would be charged during working hours.

At Brynn, where we have made experiments on safety lamps, and which are being continued by Mr. Smethurst, there is a most important item to assist in the successful and practical pursuit of such an investigation, viz., a good supply of pure firedamp from that most dangerous of Lancashire coal mines, the Wigan six or nine feet.

After proceeding with our experiments for some time, we had to admit that many of the researches we should wish to pursue, to render our tabulated tests anything like complete, would occupy more time than we could devote to them, and we consider the experiments made thus far are only preliminary ones. Had we not promised to bring the subject forward at this meeting, we should certainly have delayed doing so.

We found, in conducting our experiments, that we must study the results obtained by other experimenters as far as possible, and in doing so, we searched some of the standard mining works, and were surprised to see how meagre is the information given on safety lamps.

Our surprise on this point was intensified when we found so long ago as the year 1833, a Dr. Priara questioning the safety of the Davy lamp, and it is also a curious fact that more persons having no experience of its use have questioned its safety, than those who have, and it would be hard to explain how it is that we have gone on working with this lamp for so many years in fancied security in spite of most definite warnings of its insecurity in a low velocity of the ventilating current.

Yet so much confidence has been placed in the Davy lamp, that in explorations, after explosions, it has been the lamp asked for and preferred before all others.

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	ft.	in.	ft.	in.
33. Magnesium limestone ?			6	9
34. Red fake			3	0
35. „ fake and clay			8	8
36. „ fire clay....			9	5
37. Magnesium limestone ?			6	8
38. Fake and clay			2	3
39. Magnesium limestones			1	6
40. Red fake and clay			5	1
Sandstone, hard....			9	1
„ in bed			4	9
Light red sandstone, hard			4	0
Red sandstone, extra hard			1	4
„ „ and beds of fake			6	4½
„ shale with bands of red sandstone.			16	2½
47. Grey pyritic sandstone			1	0
Red shale with beds of hard red sandstone			24	3
49. *Gypsum*, (called "chalk and pipe clay," by men)			0	9
Red shaly sandstone			6	9
„ sandstone with a shaly appearance			20	6
Shaly sandstone and gypsum			20	0
Sandstone, with carb. and sulph. of lime			17	6
54. Ditto			6	0
55. Ditto			14	6
			710	0

Mr. Reid is of opinion that the beds 33, 37, and 39 are not truly referable to the magnesium limestone; Mr. Morley, C.E., however, considered these beds to belong to that formation, and the lower part of the boring to be in the lower permian sandstone.

Still further west, two borings for coal were put down at Woodhead, near Great Smeaton, in 1789, by General Lambton, the one 396 feet deep, the other 444 feet.

The following section is given in the Geological Society's Transactions, Vol. IV.:—

WOODHEAD BORINGS, 1789.

				ft.	in.	ft.	in.
1.			Soil and brown clay...	24	9	4	0
2.			Dark strong clay, with white boulders			20	9
3.			Red metal stone with grey girdles			48	0
			Red stone with white girdles			31	3
			Grey and white stone			4	0
			Gypsum, with flinty lumps ...			7	0
			Blue whin, with sulphur water	116	6	1	6
			Strong white post, whin girdles			6	6
			Bastard whin...			12	0
10.	231	3	Strong white post, with whin girdles			36	6
11.			Blue grey metal stone with white scars			8	0
12.			Gypsum...			2	6
13.			Soft red stone			6	0
14.			Red and white post			19	0
15.			White post with red scars.....			18	0
16.			Red, white, and grey post, red partings			27	0
17.			Soft blue-grey metal..... ...			4	0
18.			Grey and white post...			33	0
19.			Strong blue-grey stone... ...			5	0
20.			Strong white and grey stone..			60	0
21.	189	4	Whin...			3	0
22.			Mixture, whin			9	0
23.			Strong white calcareous post and white girdles...			99	4
						445	4

The 190 feet of white sandstone in the boring has been referred by some to the millstone grit, but probably belongs to the waterstone, as suggested by Mr. Peacock. He stated the sulphur spring met with in the boring, used at Middleton Spa, was also found in a search for gypsum, in a boring at Ormesburg (Mr. Pennyman's lodge gates,) near Middlesborough, in 1851, a depth of 40 feet, the section being :—

	ft.	in.
Clay and sand	7	0
Red clay	14	0
Blue metal	3	0
Ironstone girdle	0	4
Blue metal, with sulphur water at 16 ft.	16	8
	41	0

Two miles north-west of the Woodhead boring at Eryholme, a boring was put down in 1809, by Mr. George Allan, M.P., of which the following account is given by Mr. Peacock :—

		ft.	in.	ft.	in.
Sand				12	0
Clay and cobble stones	Drift,			16	0
Quick sand..	34 ft.			2	0
Cobbles and sand		34	0	4	0
Red sand post (water)				60	0
Grey sand post				3	0
Ditto, rather hard clay following				121	0
Red soft sand post				3	0
Strong red post				300	0
Soft red post, not so red				12	0
Hard dark-red post				90	0
Clay and post				3	0
Red post				24	0
Flooring ..... Grey				1	0
Hard grey post beds.				12	0
				666	0

Coatham Boring, 1867, (communicated by Mr. Peacock, M.E.) :—

			Depth. ft.	Depth. in.	Thickness. ft.	Thickness. in.
	1.	Clay	6	0	6	0
Lower Lias.	2.	Blue shale, with dagger band ...			39	0
	3.	Nodular band			1	6
	4.	Blue shale			1	8
	5.	Nodular band			2	0
	6.	Blue shale			6	4
	7.	Nodular band			1	6
	8.	Blue shale			21	0
	9.	Bastard post grey			5	0
	10.	Blue shale, with hard band			33	0
Rhætic.	11.	Dark shale, with sulphuretted band	165	0	12	0
	12.	White and grey post, with water *(brine)*			9	0
	13.	Red and white mottled post, and blue and white			12	0
	14.	Dark blue metal, with whin girdles			19	0
	15.	White shale	223	0	18	0
Keuper Marl.	16.	Red marl, mixed with gypsum			74	0
	17.	Whin band...			0	2
	18.	Red marl	118	6	23	0
	19.	Whin band...			0	3
	20.	Red marl, strong			7	0
	21.	Gypsum			1	4
	22.	Red marl	341	6	0	9

Works for the manufacture of salt formerly existed at Tod Point, but Mr. Peacock states whether sea water or the brine spring from the sea was used, is doubtful. About 1856, a 6 feet shaft was sunk on the marsh near Coatham, by the late Mr. Slate, of Redcar, in a fruitless search for

coal, a strong brine was met with, to find which the above boring was put down to find, but the brine spring met with did not realize expectation.

This boring is valuable as showing the actual junction of the lias and marls with gypsum, which latter, as pointed out by Mr. Peacock, are 28 yards thick in the Middlesboro' boring. The limestones, thick salt beds, and gypsum in that boring, are probably referable to the Permian, the intervening beds of red sandstone, 673 feet, are probably referable to the Water Stones and Lower Mottled Bunter, the Upper Mottled and Pebble Beds having thinned out.

In conclusion, it would appear that a gradual overlap eastwards, takes place in all the triassic strata, along a north-east and south-west line, the more marked transgression being that at the base of the Keuper Waterstones, and at the base of the Pebble Beds of the Bunter. Lines of extensive erosion occuring at the base of the Keuper building stones and conglomerates, and on the base of the Pebble Beds of the Bunter. The great thickness of these triassic deposits in the north-west, is proved by these borings, and and their thinning out to the south-east, is established, and has an important bearing on the depth to concealed coalfields as well as on the water bearing capacity of the Triassic Sandstones.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XV. SESSION 1878-9.

An ORDINARY MEETING of the Members of the Society was held on Tuesday, the 25th March, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

E. W. BINNEY, Esq., F.R.S., Vice-President, in the Chair.

SAFETY LAMPS.

By Messrs. WILLIAM SMETHURST, F.G.S., and JAMES ASHWORTH, Mining Engineers.

The most important question a mining engineer of the present day has to decide, on the opening up or continuing the safe working of coal mines, is which safety lamp he ought to choose, out of the large number now invented, to ensure the greatest security for himself, his workmen, and the mines under his care, amidst the ever varying conditions met with in their working.

Hitherto this decision has been left entirely in the hands of the mining engineer, and the consequence is that he has generally chosen the safety lamp which his training has led him to consider the best.

It is singular that our Government should have allowed so much latitude in the lighting of mines giving off firedamp, when we consider the stringent regulations enforced by Acts of Parliament to protect persons working in such mines, and there can be little doubt that if this question had only received greater attention, we should not have had so many lives lost by explosions during the last few years.

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Only those lamps approved of by the Commission referred to, and made according to the proportions specified in the decree, are allowed to be used in Belgium in mines giving off firedamp.

And we may here express our hope that the Royal Commission just appointed by our own Government may, after full investigation, report in favour of a similar law, as the importance of having some additional compulsory regulations regarding the lighting of mines has been forced on the attention of everybody, and ought not to be delayed longer than is compatible with a very careful enquiry.

A few months ago the Council of the North of England Institute of Mining and Mechanical Engineers considered that this question required the immediate attention of our

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The attention thus called to the safe lighting of mines caused the North of England Institute of Mining and Mechanical Engineers to appoint a committee to thoroughly investigate the question, and five years were spent in experimenting before they presented their second and final report in December, 1867, which contains the following evidently reluctant admission: "They were obliged to make "known the insecurity, under certain conditions, not pre- "viously fully appreciated and realized, of the safety lamps "so long looked upon as the safeguard of the miner."

This committee did not conclude their labours before they had tested a safety lamp of the Clanny type, with an improvement suggested by Mr. Lindsay Wood, and so highly did they esteem it, that it was proposed to call it the "Institute Lamp."

The improvement was very simple, and consisted in placing a gauze of small diameter, and rather shorter than the height of the glass, immediately over and surrounding the flame, but it does not appear to have come into general use, probably from the fact that it would give a very deficient light, and the small gauze would soon be sooted up.

These experiments were followed, in the year 1876, by the report of the Belgian Commission before referred to, which made a very extended and careful series of experiments without going over the same ground as the North of England Institute—in fact, beginning, where the latter left off.

Again the result had a practical ending, as the Belgian Government adopted the suggestions of their Commission,

and made the use of the Mueseler lamp, of certain specified dimensions, compulsory throughout all mines giving off firedamp.

We are enabled to place before you a translation of the whole of the experiments; firstly, through the kindness of the Chief of the Belgian Mining Department; and, secondly, through the practical assistance of Mr. C. G. Jackson, of the Wigan Coal and Iron Company, who has taken a great interest in our tests.

Before stating the results of our own experiments we will shortly give a history of the safety lamp.

The first attempt to light a mine giving off firedamp by anything excepting a candle, or other open light, was by phosphorescent fish skins; secondly by the steel mill, which was only safe up to a certain point; and thirdly by Dr. E. M. Clanny's first safety lamp invented in 1813.

This lamp deserves particular notice, as it was the first lamp ever taken into an explosive atmosphere, viz., on November 20th, 1815, without accident; its safety consisting in the fact that the air necessary for the combustion of the flame was blown into the lamp through a stratum of water in the bottom of the lamp by a pair of small bellows, whilst the heated gases passed out through a recurved tube at the top.

Dr. Clanny then made another lamp, in which he introduced the steam of water generated in a small vessel at the top of the lamp, and heated by the flame. Both these lamps were too clumsy for the ordinary work of a coal mine, and required the constant attendance of a boy to work the bellows.

It was not until three years later that the lamps which are still in general use were designed by Sir H. Davy and Mr. Stephenson.

During the interval, Mr. Tennant had noticed in his "Researches on Flame" that burning gases would not pass

through tubes of a certain diameter; and this principle Sir H. Davy further applied by discovering that flame would not pass through a great many appertures, when their depth was equal to their diameter.

Sir H. Davy communicated his discovery to the Philosophical Society in 1816, in a paper entitled "An account of "an invention for giving light in explosive mixtures of "firedamp in coal mines by consuming the firedamp," and in January, 1817, a further paper on "Some new experi- "ments and observations on the combustion of gaseous "mixtures, with an account of a method of preserving a "continued light in mixtures of inflammable gases and air "without flame."

Mr. Stephenson in his invention applied the principle that burning gases would not pass through tubes of a certain diameter, as his original lamp consisted of a glass cylinder with a perforated metal cap, to allow the heated air to escape, and a series of perforations in the bottom to admit the air necessary for the combustion of the flame, and the whole being surrounded by a sheet iron covering, containing large round holes to allow the light to pass outwards.

In the Stephenson lamp of the present day, this sheet iron covering is replaced by gauze, which constitutes practically the only difference between the form of the lamp as originally constructed, and the one now in every-day use.

Dr. Clanny, not disheartened by the practical failure of his first two lamps, invented and constructed another in the present well known form.

If we were to describe the whole of the safety lamps which have been invented since the three already described were brought out, we should find that the general principles of all of them originate from the Davy, Stephenson, and Clanny types, with the addition of metallic tubes in some instances.

The number of lamps invented between 1852 and 1875 averages about six per annum; and great efforts have evidently been made to invent lamps with locks that cannot be tampered with, or if tampered with, will cause the extinction of the flame, and, also, to ensure the total extinction of the flame when firedamp explodes in the lamp.

Of *locked* safety lamps, the best known types are those with the screw lock, the padlock, Craig and Bidders' magnetic lock, the lead rivet, and Teale's protector lock.

Of the type of lamps which are *self-extinguishing* when the firedamp explodes in the lamp, the best known are the Stephenson and the Mueseler.

Of improvements to produce a *better and more brilliant light*, we may name the Mueseler, the Williamson, and all classes of lamps using colzaline oil; and we wish to observe in passing that firedamp can be more easily detected by lamps using this oil than by lamps using ordinary lamp oils, this effect being due to the clearness of the flame.

Of safety lamps of *improved construction*, the numbers are too numerous to make it worth while giving a list, but the following are in actual use: the Mueseler, the Bainbridge, the Williamson, and the Pelton. Most of the lamps unnamed, although safe, are either too complex in their construction, too heavy (for instance the electrical lamp) or have some great fault which their non-practical inventors could not realize.

Of safety lamps *for use by firemen* in making their daily inspections, no lamp has in this country yet replaced the Davy or the Stephenson (with a shorter glass cylinder than ordinary workman's lamp), although a smaller percentage of gas can be more readily detected by the Muessler than by any of the above-named lamps.

The continued use of the Davy and Stephenson lamps by firemen probably arises from the fact that they are more

adapted to the ordinary method of shot lighting than any other form of safety lamp.

A difficulty is here met with in the shot lighter, who must use a lamp so constructed that he can heat his wire in the flame, and still have as safe a lamp as any in the mine; his lamp being often put to more severe tests than any other, and if a blown out shot takes place it would be the first to receive the concussion, the increased velocity, dust, and heated atmosphere. So far as our experiments have gone, the best and safest lamp to be used by a shot lighter is one of the improved "Jack" Davy lamps, referred to in this paper.

When commencing our experiments, we decided to construct with wooden boards a model of a coal working, consisting of two levels, and a cut through of 12in. by 6in. section, and three drifts out of the top level 12in. by 12in., with a brattice up the centre, with glasses placed in the sides in various places, to enable us to observe the effect produced when an explosion occurred.

We placed a sound Davy lamp at the top end of the drift (No. 3) nearest the upcast, filled No. 2 drift with gas, and then charged the ventilating current, which had a velocity of 9ft. per second, with a certain amount of gas, and as soon as the gas showed in the lamp the brattice in No. 2 was altered to allow the gas stored up to be carried by the current on to the lamp, resulting quickly in a heavy explosion which did practically no damage in the drift where the lamp was, nor in No. 2 except to split the boards on the top and bottom, but No. 1 and the cut through were completely destroyed, although the wood was oak boardings of $1\frac{1}{4}$ in. thick. This experiment was repeated with exactly the same result, thus showing in an experimental way that the greatest damage is not necessarily caused at the seat of the explosion.

After this experience we used only the straight level with escape doors, to give the force of the explosion free exit.

The velocity of the air current was regulated and maintained by a steam jet, and in our later experiments registered by a Dickinson's aneomometer up to 11ft. per second, and by a Biram above 11ft.

In all our latest experiments, the Dickinson was constantly in the tube, and the velocities were accurately taken at the exact time the explosion occurred, and all variation in the velocities during the tests were also accurately registered.

The records of our earlier experiments are not so complete as we could have desired, in consequence of the breakage of the Dickinson anemometer.

The lamps we have experimented on so far are:—

Davy type.—Ordinary Davy, large and small Scotch lamps, improved Davy by Mr. Smethurst, Do. do. by Mr. Ashworth and Mr. Woolrych, Davy of small diameter of gauze by Mr. U. E. Dickinson, and "Jack" lamps.

Clanny type.—Large and small Clanny's, Mueseler's lamps by various makers, Williamson, Pelton, Bainbridge, Eloin, Gray, Glover, and Cail.

Stephenson type.—Ordinary Stephenson and Williamson. With the following results:—

An ordinary Davy, with the shield down, in a velocity of pure air of 20ft. per second, without gas, and the flame facing the current, went out in 45 seconds.

Do., with shield towards the current, went out in 4 seconds to 15 seconds.

Tests with velocity of 20ft. over 3 minutes of time:

Davy, with shield up, went out at once.

Clanny lamp, in the same velocity, went out in 3 minutes; light very flickering; not a working light.

Williamson, in the same velocity: light very flickering; not a working light; not out.

Ashworth and Woolrych's Davy: flickering light, but steadier than the others; not out.

Stephenson: light very flickering.

Small Mueseler: good working light, and steadier than the others.

Ashworth's large Mueseler: very steady light.

Tests with velocity of 38 ft. per second over space of 3 minutes.

Clanny: very little light; out in 1 minute 7 seconds.

Stephenson, with large flame: not a working light at all; not out.

Ashworth and Woolrych's Davy—Teale's oil: flame very flickering; not out.

Small Mueseler: light much reduced; not a working light; not out.

Ashworth's large Mueseler: steady working light.

Some details of the experiments are set forth on the next page.

SAFETY-LAMP EXPERIMENTS,

Made at various times in the presence of Messrs. Dickinson, Hall, & Martin, H.M. Inspectors of Mines; Messrs. Wm. Bryham, C. F. Clarke, — Cockson, F. Crippin, U. E. Dickinson, W. Ellis, C. Fergie, W. Harbottle, W. H. Hewlett, C. G. Jackson, John Mitchell, M. Mercer, G. Peace, John Smethurst, H. Stock, W. Topping, mining engineers; Mr. Wm. Pickard, miners' agent; and many managers and underlookers.

Description of Lamp.	Diameter of Gauze.	Velocity in Feet per Minute.	Time.	Position of Shield.	Remarks.
			Min. Sec.		
Davy Lamp.....	$\frac{7}{8}$	430	0 50	No shield	Exploded.
Do.	$\frac{7}{8}$	600	0 $5\frac{1}{4}$	Do.	Do.
Do.	$1\frac{1}{2}$	360	1 30	Do.	Did not explode. Red-hot. Experiment suspended.
Do.	,,	380	3 0	Do.	Do. do. do. All proportions of gas and air tried.
Do.	,,	400	3 0	Do.	Do. do. do.
Do.	,,	420	0 5	Do.	Exploded.
Do.	,,	420	0 5	Up to top on intake side ..	Do.
Do.	,,	600	0 10	Do. do. ..	Do.
Do.	,,	600	0 12	Do. do. ..	Do. Copper gauze.
Do.	,,	600	0 4	No shield	Do.
Do.	,,	520	0 5	Do.	Do.
Do.	,.	580	0 3	Do.	Do.
Do.	,,	600	0 $5\frac{1}{4}$	Do.	Do.
Do.	,,	600	0 7	Do.	Do.
Do.	,,	580	0 $4\frac{1}{4}$	Do.	Do.
Do.	,,	420	0 5	Down on the intake side ..	Do.

Description of Lamp.	Diameter of Gauze.	Velocity in Feet per Minute.	Time.	Position of Shield.	Remarks.
			Min. Sec.		
Davy Lamp.....	,,	480	0 6	Do. do. ..	Exploded. Lamp direct out of pit; had been used all day.
Do.	,,	550	0 5	Do. do. ..	Do. do. do.
Do.	,,	560	0 4¾	Do. do. ..	Do.
Do.	,,	600	0 9	Do. do. ..	Do.
Do.	,,	600	0 12	Do. do. ..	Do.
Do.	,,	600	0 14	Do. do. ..	Do.
Do.	,,	560	0 4	Down on the return side..	Do. Dirty gauze.
Do.	,,	580	0 5	Do. do. ..	Do.
Do.	,,	600	0 6	Do. do. ..	Do.
Do.	,,	600	0 7	Do. do. ..	Do.
Do.	,,	600	0 5¼	Do. do. ..	Do.
Do.	,,	600	0 8¼	Do. do. ..	Do.
Do.	,,	600	0 5½	Do. do. ..	Do.
Do.	,,	600	0 5¼	Do. do. ..	Do.
Do.	,,	600	0 2¾	Do. do. ..	Do.
Do.	,,	440	0 22	Glass shield all round	Do. } Smoke gauze covered by glass shield
Do.	,,	580	0 14	Do. do.	Do. } to the extent of ¼ of an inch.
Do.	,,	500	3 0	Do. do.	Did not explode. } Smoke gauze covered by
Do.	,,	600	6 20	Do. do.	Do. } glass shield to the extent of ½ an inch. Experiment suspended.
Stephenson, without inside glass cylinder	2	500	0 7	No shield	Exploded.
Do. do. ..	2	600	0 9	Do.	Do.
Small Scotch Gauze	2¾	600	0 3	Do.	Do. Lamp from Blantyre.

Description of Lamp.	Diameter of Gauze.	Velocity in Feet per Minute.	Time.	Position of Shield.	Remarks.
			Min. Sec.		
Small Scotch Gauze	,,	600	0 6¾	3in. × 6in.	Exploded.
Do.	,,	600	0 3	Shield on return side	Do.
Large Scotch Gauze	3½	600	0 1½	No shield	Do.
Do.	,,	180	0 5	Do.	Do. Standard mesh.
Do.	,,	600	0 1	Shield 2⅝in. × 5½in.	Do.
Do.	,,	600	0 6	Shield up to the top of the gauze	Do. 23-mesh gauze.
Do.	,,	600	0 11	The whole height of the gauze on the intake side.	Do. Standard gauze.
Do.	,,	600	0 8	Do. do. ..	Do. do.
Do.	,,	600	0 1½	Do. on return side.	Do.
Do.	,,	600	0 8	Do. do. ..	Do. 23-mesh gauze.
Davy-Teales Jack Lamp ..	..	565	0 19	Cylindical glass	Do. (Mr. Pickard's lamp.)
Do. do. ..	..	600	1 28	Do.	Do. Glass cracked, but not broken.
Do. do. with Mr. Smethurst's Chimney	..	600	3 0 3 15	Do.	Gauze red-hot for three minutes suddenly increased the velocity, and the flame passed through and exploded the gas.
Do. do. ..	..	580	0 50 2 40	Do.	The glass cracked and broken at 2min. 40sec., and experiment suspended.
Do. Ashworth and Woolrych.....	1 & 1⅝	..	4 30 14 0	Do.	Glass shield cracked up completely, but did not fall away, as some of the glass fuzed into the wire mesh. The velocity of the air and gas varied in many ways, and the proportions varied, but the gas was not fired when the test was suspended, after 14 minutes.

From the above experiments on Davy lamps of various constructions it will be seen that the results obtained from tests with the same lamp do not agree, and this is accounted for by our inability to regulate the proportions of gas and air accurately. We made many experiments to find out what proportions of gas and air formed the most explosive mixture, but our apparatus was not sufficiently delicate to do so.

With reference to shields, it will be observed that the ordinary lamp shield is no safeguard at all, and a cylindrical glass shield only becomes such when it overlaps the top, or smoke gauze, to the extent of half an inch or more. So clearly have our experiments demonstrated this fact, that Mr. Topping, one of the Mining Engineers who witnessed them, had a Davy lamp altered to comply with this condition, and then tested, and has now altered, or is altering, all his Davy lamps accordingly.

Description of Lamp.	Diameter of Gauze.	Velocity in Feet per Minute.	Time.	Position of Shield.	Remarks.
			Min. Sec.		
Stephenson Lamp	..	..	..	.. ..	A few tests have been made with this lamp without explosion; but as the Williamson lamp, which is practically of the same principle, passed the flame easily, they were not pursued.
Clanny (Dialing Lamp)....	1½	400	..	.. ..	Copper gauze. Wick flame extinguished, but the gas continued to burn in the gauze, increased the proportion of gas, and extinguished the flame. Time not taken.
Do. Large	1½	620	0 3½	.. ..	Exploded. Gauze bulged slightly.
Do. do.	,,	600	0 3	.. ..	Do.

Description of Lamp.	Diameter of Gauze.	Velocity in Feet per Minute.	Time.	Position of Shield.	Remarks.
			Min. Sec.		
Clanny, Small.....	,,	600	0 4	.. ..	Exploded.
Bainbridge's Lamp.....	....	600	0 3	.. ..	Do.
Do.	....	600	0 3	.. ..	Do.
Williamson's Lamp	....	360	....	.. ..	Do. After the wick flame was extinguished, the gas continued burning at the top of the inside glass cylinder for 33 seconds, and in increasing the velocity to 450, the flame passed and exploded the gas, glass cylinder slightly cracked at the top but not enough to impair its safety.
		450	1 38	.. ..	In the case of some other experiments, the gas did not continue to burn and therefore the flame did not pass.
Glover & Cail's Lamp	....	700	0 2½	.. ..	The gas continued to burn in the top of the gauze after the wick flame was extinguished and the flame passed and exploded the gas.
Do.	....	600	0 2	.. ..	Do. do.
Gray's Lamp	....	600	0 3	.. ..	Went out. A heavy lamp and an insufficient outlet for the products of combustion.
Eloin Lamp.....	....	620	....	.. ..	Went out at once. A very sensitive lamp, in fact too much so for use in actual work.
Mueseler Lamps:					
(Mr. Dickinson's) ..	....	600	0 3	.. ..	Exploded.
Do. ..	....	500	....	.. ..	Do. Defective disc gauze not timed.

Description of Lamp.	Diameter of Gauze.	Velocity in Feet per Minute.	Time.	Position of Shield.	Remarks.
			Min. Sec.		
(Liége make)	....	600	....	.. ..	Exploded. This is the only instance out of the very large number of experiments made with this lamp that it exploded the gas, and being unexpected was not timed. In every other instance the light went out quickly and quietly as soon as the gas fired in the lamp.
(Another of Mr. Dickinson's English make)	....	1000	3 20	.. ..	Did not explode with the few tests made. The proportions of the lamp are similar to the Liége. Glass slightly cracked.
Teale's	....	600	0 10	.. ..	Wick light extinguished, but the gas continued burning under the disc gauze and cracked the glass—experiment suspended. No other experiment made with this lamp.
Pelton Lamp	....	640	0 1	.. ..	Inside glass cracked. Light very flickering.
			1 30		More gas added.
			3 37	.. ..	Light extinguished. Experiments were made with this lamp up to 1000 feet per minute, but in no case did an explosion result. The construction of the lamp is such that a steady light cannot be maintained. It is also both complex in its construction and heavy.

From the list of experiments on Davy lamps, it will be seen that the smaller the diameter of the gauze the greater is the resistance to the flame passing, arising from the fact that the volume of gas burning inside the small gauze is not sufficient to heat it so quickly as the large volume contained in such lamps as the Scotch gauze lamp.

It will be plain from the experiments that a Scotch lamp ought not to be classed as a safety lamp at all, and where used as such, immediate steps should be taken to replace it with a proper safety lamp.

From the list of experiments we deduce the following facts :—

1. That the greater the diameter of the gauze the quicker will the flame pass.

2. That, in an explosive atmosphere, with the low velocity of seven feet per second, and without coal dust, the Davy lamp, as ordinarily constructed, is unsafe.

3. That, whatever may be the height of the tin shield, it is no protection or safeguard against the flame passing; in fact it adds to the danger.

4. That, if a cylindrical glass shield is used, as in the "Jack" lamp, and the smoke gauze made so long that the glass shield overlaps it by over a quarter of an inch, the safety of the lamp is immensely increased, and the flame will not pass until either the glass is broken up by the heat, or the double thickness of gauze becomes heated sufficiently for the flame to pass.

5. That a Davy lamp constructed after the design of Mr. Smethurst's Jack lamp, or Messrs. Ashworth and Woolrych's Jack-Davy lamp, is still safer.

6. That, in many cases, a Clanny lamp cannot be considered any safer than a Davy lamp, and this remark will also apply to the Bainbridge lamp.

7. That a ventilating current, containing a very small

per centage of gas, just enough to elongate the flame, and followed by a highly explosive body of gas, is the most severe test that a lamp can be put to, and very few can stand it. This fact is also noticed by the Belgian Commission.

We regret that we have not had time to make a proper series of tests with coal dust, combined with firedamp and air; but we may state, as showing the importance of this part of the enquiry, that Mr. Galloway, in his most recent experiments, has proved that a mixture of some coal dusts (not all) and air, at the ordinary pressure and temperature, becomes inflammable when 0·892 per cent. of firedamp is added, and it then burns with a red smoky flame.

To test the effect of concussion we made a few tests, none of which were successful; but having seen successful experiments of this class, we are satisfied that if an ordinary Davy lamp is standing in an explosive atmosphere, or if an explosive atmosphere suddenly surrounds the lamp at the moment of concussion, the flame will pass the gauze without its becoming red hot.

As probably some expression of opinion will be expected from us, with respect to the lamps we have tested, we state most emphatically that the Davy lamp, as ordinarily constructed and in daily use, is not safe in coal mines giving out firedamp; more especially as their working necessitates increased ventilation, and therefore, at least in some parts, increased velocities.

A lamp, to be a good and safe lamp, must give the maximum quantity of light, and thus remove one great temptation to the opening of the lamps clandestinely, and further the light must be a steady one in a current of the the highest velocity.

The lock should be simple and effective, and the opening of the lamp should extinguish the light.

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The lock should be simple and effective, and the opening of the lamp should extinguish the light.

The lamp should be self-extinguishing in an explosive atmosphere.

Every lamp should be made according to such proportions and dimensions as experiment has proved, or may prove, to be the safest.

The workmen's lamps should be cleaned at the colliery, and be delivered to the workman ready for use, without further examination, excepting so far as regards the locking; and, where practicable, every lamp should be tested as it comes out of the pit; and a new lamp before it goes down, by placing it in an explosive atmosphere. (This test is now carried out at some collieries.)

Of all the lamps we have tested, the one that gives the steadiest and best light, simple construction, and self-extinguishing, is the Mueseler; and it is also the best for proving the existence of a small percentage of gas in the ventilating current.

The Clanny lamp is very little, if any, safer than the Davy lamp.

The Eloin is quite safe but too sensitive, the Gray and the Pelton are safe but very heavy, the latter being complex in its construction, and giving a very poor light, excepting in a nearly still atmosphere.

It is important that the oil used should be the best that can be bought, and should be free from admixture with explosive oils, as the Belgian Commission found that this admixture lessened the safety of the lamp. Here, again, is another objection to workmen cleaning their lamps at home, because many of them buy inferior oil, which is only made burnable by the addition of large proportions of paraffin or petroleum oil.

In conclusion, we may state that the experiments are still being carried on, and the result we trust, will prove

of a practical nature, and tend to lessen the risks now incurred.

The CHAIRMAN said they must all feel obliged to the authors of the paper for their patient investigation of this subject. Many years ago—certainly over thirty—he heard the Davy lamp condemned, but the unfortunate term "safety" had enabled it to outlive opposition. He heard the late Mr. Livesey, many years since, mention an instance of an explosion arising from a Davy lamp under very ordinary circumstances. What seemed to strike him in the paper just read was the thoroughly practical nature of the experiments which had been made.

Mr. SMETHURST said there was, at their colliery, ample opportunity for testing any lamp. The experiments were conducted on the surface: they had gas piped off from the 6ft. mine, which was not now being worked. The seam yielded large quantities, and the arrangement described had been made so that they could test any lamp in a second or two by actual coal gas.

Mr. DICKINSON said he had, on two occasions, had the opportunity of seeing Mr. Smethurst's experiments, and was therefore, perhaps, more conversant with the subject than some of those who had not had the same opportunity. Before the discussion was entered upon, he would like to allude to three points in the paper: 1st. the reference to the Government not having taken the same interest in placing in the hands of the miner a safe lamp, as they had taken with regard to other measures of safety. He might say that when application on that point was made to Mr. Cross, the Secretary of State, by Messrs. Ashworth and Smethurst, he took a lively interest in the matter, and expressed his desire to favour their views so far as

possible; and it was only when the matter was brought under the notice of the Treasury that, seeing the difficulties which might arise with respect to other inventors, the Government thought it had better be left in the hands of the public. The second point in the paper was with regard to the name "Blantyre" given to the Scotch lamp. He thought if it were called a Scotch lamp it would be better appreciated by the Blantyre people, as they did not consider it their lamp at all. The third point was with respect to the shield. There were different kinds of shields to safety lamps, and different kinds were used in making the experiments. Those made of glass encircling the lamp gave greatly increased security; but the ordinary metal shield which only encircled one-half of the lamp, when facing the current, hastened the passage of flame through the gauze considerably. He considered the latter point particularly worthy of the attention of members taking part in the discussion.

Mr. SMETHURST said, with regard to the first point, the remark alluded to in the paper did not apply to the Government since these experiments began, but previously. He thought the Government had not gone properly into the matter when framing former Acts of Parliament. In the paper only one Blantyre lamp was mentioned, and it actually came from Blantyre, having been brought by Mr. Pickard. He thought, also, that it was mentioned in the paper that, with the ordinary tin shield, the lamp was more unsafe than without. In the glass shield they had, of course, quite a different thing.

The CHAIRMAN: It is rather a singular fact that Sir Humphrey Davy recommended the shield especially, because, he said, when there was a current it rendered the lamp much safer.

Mr. SMETHURST: We found that, with the shield—its face being against the current — the light was thrown

upwards, so that the flame impinged against the lamp, just over the top of the shield, no matter how high that was. The consequence was, the whole heat became concentrated on one point, whereas, without the shield, it heated all the gauze before the flame passed.

Mr. GEO. WILD, referring to the narrow and wide-gauze Davy lamps, said his (Mr. Wild's) experiments were made with a blower of gas impinging against the gauze of the lamp, and he found that the narrower the gauze the sooner the explosion occurred. The wide-gauze Stephenson lamp took a much longer time to explode than a narrow gauze.

Mr. SMETHURST said that Mr. Wild's experiments, with a blower of gas, were quite different from theirs, where the several lamps were placed in a small model of workings, the whole atmosphere contained in which was impregnated. They tried different sizes of gauze cylinders, from $\frac{7}{8}$ inch upwards, and always found that the smaller the diameter of the cylinder the greater the safety. If any member of that Society would like to see a lamp tested, every possible facility should be given him for his doing so.

Mr. WILKINSON asked if it was not a great objection to the Mueseler lamp that if inclined at the least angle it went out? Were the mines in Belgium flat or steep mines?

Mr. SMETHURST said the Mueseler certainly did go out, in an inclined position, but, with the new regulation chimney or funnel, it might be placed at a considerable angle before it went out. It gave fair warning before it began to go out. This liability to go out, when inclined, was not a bad thing; it was, rather, in its favour, that it made the collier keep his lamp straight up and steady.

Mr. DICKINSON said that it was, besides, a great protection in preventing the flame from impinging on the glass and thereby cracking it. It only wanted care, with the Mueseler, to make it a lamp they could always carry without ever

losing light. He used a Mueseler for four long days at the close of last year, and never lost the light; but twice, when he gave it to a man to hold while he (Mr. Dickinson) was taking notes, the man put it out. All that it needed was care. The Belgian mines, it should be understood, were much steeper than those of Great Britain; some of them were at every conceivable angle.

Mr. SMETHURST: Our experiments, so far, have resulted in favour of the Mueseler.

Mr. DICKINSON: There are thousands of them in use in Belgium.

A MEMBER said that he had had in use for many months a modified Mueseler, and there had never been the least complaint of its going out. Their mines were at an angle of one in six. The lamps were hung upon props when the colliers were using them.

Mr. SMETHURST: Whatever you hang the lamp on, it ought to be perpendicular.

The CHAIRMAN: When I tried the Mueseler, many years ago, the colliers objected a good deal to the glass: they seemed always to have a great fear of it.

Mr. SMETHURST: And yet in Belgium the percentage of glasses broken in these lamps is very small indeed. We never had a broken glass in a Mueseler lamp yet, with all our tests.

The CHAIRMAN said that great improvements had taken place in lamps since he first knew them. He remembered the time when, in this district, a lamp was never seen in a mine; they always tried for gas with a candle, and some colliers were remarkably adroit in cutting off the flame from the candle; but now and then an explosion occurred. Then, he had seen lamps, in mines, almost red hot. He had been in a mine where there were nearly a dozen lamps in that condition. He recollected attending a lecture by the late

Dr. Murray in this city, who gravely told his audience that a lamp was safer when red hot than otherwise. That gentleman, he supposed, could never have been in a pit in his life. But, in the nature and use of lamps, far greater care was bestowed now than used to be; still it was highly desirable that these warnings about lamps not being safe should be attended to, and he hoped Mr. Smethurst's offer to allow experiments with any lamp that might be brought for the purpose would not be lost. He thought probably that there should be a committee of practical men—if any doubt existed—who should go and see the experiments, and experiment themselves. So far as he could hear, those described were the most complete set of experiments he had ever heard of. Nearly all the lamps in use, or that had been in use, appear to have been tested.

Mr. SMETHURST: We have tested almost every one. We shall be very glad if your suggestion is acted upon.

On the proposition of Mr. LIVESEY it was decided to postpone further discussion until Mr. Smethurst has presented the second part of the paper to the Society.

NOTES ON A RECENT BORING IN OPENSHAW, NEAR MANCHESTER, WITH REMARKS ON THE MANCHESTER COALFIELD, AND THE DISTRICT TO THE EAST OF IT.

By Mr. JAMES ATHERTON.

It is of the utmost importance to Manchester, the metropolis of the cotton manufacturing district, and the seat of so many other large industries, that its coal resources should at all times be both ample, and, to a great extent, nigh at hand.

The existence around Manchester of a plentiful and cheap supply of coal has undoubtedly contributed, in no small measure in time past, to our manufacturing success as a nation; and the continuance of a cheap supply will still remain one of the great factors in the now vexed question of our retaining the supremacy of the cotton trade of the world.

Manchester is, in this respect, well situated, as it is within easy distances of coalfields yielding immense supplies. Its various railway systems have at all times been the means of pouring in large quantities; and, in addition to these contributions by rail, great resources have always been at hand from the immediate neighbourhood, and within easy carting distances. Manchester could hardly have done without the coal brought by rail; but its greatest indebtedness is undoubtedly to the coalfields of Bradford and Clayton on the one side, and of Pendleton and Clifton on the other.

As regards the latter district, its many mines are well known, and its large resources can be estimated with satisfaction; but, as regards the former district, there has not hitherto been the same cheerful reliance. The number of the mines which could be counted on was not very clearly ascertainable, and unless others were found beyond those known a few years ago, the life of this field would have been very short.

Known under the name of the "Manchester Coal Field," it consisted of the "Upper Coal Measures," which are probably here better developed than in any other part of our country. These "Upper Measures" consisted of nine coal seams, six of which have been more or less worked. The names of the latter, in descending order, are the "Openshaw," "Charlotte," "Three-quarters," "Four-feet," "Yard," and "Two-feet," all being of pretty good quality.

The area of the field is little more than three square miles. It is bounded on the north and east by faults, whilst on the west it runs under the Permians for a distance, and will no doubt eventually be found to be there cut off by a fault, which will again throw the measures up.

The dip is about one in three, and a little south of west. The thickest mine, and in all respects the principal one, is the Four-feet Mine.

It is of very good quality, a clean, bright coal, and has been very extensively worked; indeed, it may be said to be now almost exhausted. The other mines being thinner, have only been partially worked, and the additional expense required to work thin mines will no doubt prevent them again being worked to any great extent, so long as thicker mines exist in the neighbourhood. There is in the area an almost entire freedom from faults, besides which very little water requires to be pumped; and these facts, coupled with the nearness to the city and the quality of the mines, have rendered this coalfield, though small, yet a very valuable one.

The rapid exhaustion of this field of late years aroused much anxiety as to its future, if indeed it had any future at all. The four-feet mine had been usually considered to be the same as the Worsley four-feet mine at Pendleton, and, as the "Middle Coal Measures" had there been sunk to, Messrs. Livesey, of the Bradford collieries, determined also to sink to these middle coal series.

It was assumed that the "Crumbourke" of Pendleton would be found at about 300 yards below the four-feet mine, but after sinking at considerable expense to that distance they met with disappointment. No doubt Messrs. Livesey had many anxious thoughts as they proceeded deeper and deeper, and still without success, nor would they be at all cheered if they referred to Mr. Hull's Memoirs of the

Geology of this District, to read that "No coal seam of sufficient thickness for working will be found at a less depth than 616 yards below the Bradford Four Feet Mine." Their patience and endurance, however, were not put to that extreme test, as they had the satisfaction of reaching the "Parker Mine," both of good quality and of workable thickness, at a depth of some 450 yards below the four-feet mine.

It is somewhat remarkable that, as between the "Lower" and the "Middle Coal Measures" there is a considerable interval of barren measures, so also between the "Middle" and the "Upper Coal Measures" there is a great depth of strata barren of workable mines. But the similarity ends here, for the character of the strata forming these two barren zones is very different. That in the lower zone consists of sandstones and shales much like the usual sandstones and shales found associated with the coal seams: but in the higher zone there occur shales and sandstones of a purple, red, or mingled character, and very unlike those usually found with the coal seams, whether of the lower, middle, or upper series.

There can be no question that these purple and other coloured shales and sandstones have often been mistaken, and supposed to belong to other than the carboniferous system. They are not very well known. In South Staffordshire, where they occur in force, they have often been supposed to belong to the Permian, whilst others have classed them with the "Old Red," instead of in their proper place as true coal measures.

Any information as to this strata, would therefore be very welcome, and Messrs. Livesey would confer a great public boon by communicating to this Society a complete section of the measures passed through by them in their sinkings.

I have no doubt there are many parts of our country where these purple beds are at or near the surface, and

where coal has not been expected, which will yet be discovered to form valuable coalfields.

Which mine the "Parker Mine" will correspond with in the Pendleton or the Ashton series, does not yet appear, but it will probably prove to be one of the mines immediately overlying the Great Mine of Ashton. If this be so, then the life of the Manchester Coal Field is indefinitely prolonged, and the underlying mines will form a vast accession to the coal resources available for Manchester.

Whilst Messrs. Livesey, of the Bradford Colliery, were thus endeavouring to prove what was under the four feet mine, it became necessary at the Clayton Colliery to be looking forward, and to consider what should next be done. The mines there abutted against the eastern boundary fault, and beyond this fault the new red sandstone was thrown in. This fault was known to be a large downthrow, but the extent to which the upper coal measures might be thrown down could not clearly be ascertained.

Mr. Bradbury, of the Clayton Colliery, had proposed at some time to cut through this fault at a depth of some 400 yards from the surface, in order to find out what lay beyond, but as the new red and Permian measures are almost invariably very heavily watered, the cutting was deferred until the four feet mine should be almost worked out. Owing, however, to an accidental circumstance, this determination was never carried out, and the fault remained uncut.

It then became a very desirable matter to ascertain, either by boring or otherwise, to what depth the mines were thrown down on that side, and of greater importance still to know exactly to what depth the Permian water bearing measures extended, so that in case of cutting through the fault so as to work any mines under the Permian, a sufficient barrier might be left overhead so as to avoid bringing the Permian waters down into the mines.

At the beginning of last year a boring was agreed upon. Application was made to Messrs. Mather and Platt, of Salford, and to the "Cumberland Rock Boring Company," for the terms on which they would conduct a boring to a depth of say 1200 feet, and after consideration those of the latter Company were agreed to.

They were for a specified sum to a depth of 600 feet, and so much per foot for every 100 feet afterwards, and were to cover all costs and risks.

J. Vivian, Esq., C.E., who is the representative of the C. R. Boring Company, then came over, and the site of the borehole was fixed upon, and all arrangements made for commencing the work at once.

It was begun at the end of April, and was continued by hand until the boring machine was put up.

The engine and machine were got ready for work early in May, and by the 1st of June the depth bored was 279ft.

By the 1st July ..	523ft.	By the 1st Oct. ..	1110ft.
,, 1st Aug...	840ft.	,, 1st Nov. ..	1210ft.
,, 1st Sept...	1022ft.	,, 7th Dec. ..	1300ft.

The hole was lined with tubes, the sizes and lengths being as follows :—

9in.	diameter	to a depth	from	surface	of 25 feet.
8in.	,,	,,	,,	,,	49 feet.
6¾in.	,,	,,	,,	,,	112 feet.
5¾in.	,,	,,	,,	,,	559 feet.
5in.	,,	,,	,,	,,	1019 feet.

and 4½in. below.

The machine for boring is, no doubt, sufficiently familiar to most of the members of this Society, but as some may not have seen it, a brief description may be desirable. It is somewhat in the form of a triangle, the uprights and base forming the two sides, and the back the hypothenuse. The uprights are about 10ft. in length, and the base is also about

10ft. long. Within the triangle are included what appear to me quite a triumph of mechanical appliances in small compass. There is a pump for forcing water down the borehole, at a very considerable pressure, and which is also used for feeding the boiler. Then there is a powerful steam crab for lifting the rods. This can be put out of gear so as to let the rods down quickly when lowering. There is, then, the gearing for causing the boring rods to revolve, and a dead weight balance to act as a counterpoise to the weight of rods in the hole. This is capable of adjustment from day to day. Besides these, there is an arrangement whereby, during the progress of the boring, the whole weight of rods may be lifted by hand for two or three feet and then let down again at any speed. The uprights form a pair of slides, between which is placed a moveable sliding headpiece. Through the centre of this the boring rods or tubes pass; they can be gripped at any point, and the whole caused to revolve quickly. The rods are not of solid iron, as in the boring tools of old days, but are of strongly made iron tubes, about two inches in diameter, with well-formed box joints.

There are no chisels or augers; but at the bottom of the rod is a core tube about ten feet long, and about $\frac{7}{8}$ths of an inch less in internal diameter than the full size of the hole.

The bottom three or four inches of this is called the "crown." In the face of the rim, and looking downwards, are fixed four or five diamonds, very slightly projecting from the metal. On the outside of the rim are about four others, and on the inside about the same number. It will now be seen that as the rods revolve quickly the face diamonds will cut down, and the inner and outer will cut a circular groove or annular ring; and that the solid part of the rock left in the centre will rise up into the core tube. Sometimes, where the rock contains few beds, the cores

(which will be about one inch less in diameter than the full size of the hole) will be in long lengths. In other cases the core tubes will be filled with many pieces.

As the boring goes on, water is forced at a considerable pressure down the inside of the boring tubes, and, there being no release for the water except from under the crown at the bottom, it there rushes out with great force, and rises up between the boring tubes and the lining tubes, carrying with it the loose sand, or soft mud, which may be made at the bottom of the hole.

The boring rods are drawn generally about once a day; but should the core tube get full in less time than a day, they of course are then drawn. A pair of shear legs stands over the bore hole, and in drawing the rods the joints are uncoupled at every ten yards.

The boring at Openshaw was carried down as before stated to a depth of 1300 feet, and when at that depth the time occupied in raising the rods, emptying the core tube, and again letting the rods to the bottom, ready for work, was about $1\frac{1}{2}$ hours.

The site of the hole is close to the boundary between the townships of Openshaw and Clayton, and about 100 yards west of the Manchester and Stockport Canal.

During the progress of the boring there were few serious accidents and few delays. This was due largely to the excellent arrangements made by Mr. Vivian. He had at hand at all times such tools as might be necessary to meet the exigencies of boring, such as breakages of rods, and other matters; and besides this, he took care to have at hand the various materials requisite for the boring, before the time they were actually required.

A detailed section of the strata passed through in the boring is appended to this paper, but a short description may here be given. The first 36 feet was through the

"Drift," which extends over so great an area around Manchester. The bore then passed into a soft bright red sandstone, terminating at 82 feet deep with a 2-inch. bed of course red sandstone, containing small white quartz pebbles. This would form the base of the Bunter Sandstone. The boring then entered the "Permian Marls," and from 82 feet deep to 150 feet, the measures consisted of red shales, with five thin beds of yellow and red sandstone. These measures were devoid of fossils. At 150 feet deep a 2-inch. bed of limestone was passed; and then to 217 feet consisted of a series of unfossiliferous red shales and sandstones. At 217 feet occurred a second band of limestone, 16 inches thick, of a brown colour, and containing shells. From 217 feet to the depth of 242 feet was a series of red shales and limestones, containing many nodules of "Gypsum," and very full of shells (mostly of the Bakevellia). For a further depth of 40 feet there were red shales with numerous layers of shells, and containing two other thin beds of limestone; and then came 2 feet 3 inches of sandstone conglomerate, forming the base of the Permian Marls.

The total thickness of the "Permian Marls" was therefore 205 feet, of which the first 135 feet showed an absence of fossils, whilst the remaining 70 feet contained many, along with the beds of limestone, and nodules of gypsum.

After passing the conglomerate, the bore-hole at once entered the "Permian Sandstone" which was found 752 feet thick. This thickness was 330 feet greater than the greatest thickness of this sandstone hitherto ascertained in this neighbourhood.

It consists almost entirely of beds of a dull brownish red colour, sometimes fine grained, and at other times somewhat coarse, but nowhere containing pebbles, or grains larger than pins' heads. Here and there it was slightly mottled

in colour; some of the beds were soft, and others much harder; whilst occasionally there occurred thin beds of shale. The grains were all waterworn and coated with oxide of iron.

The depth from the surface to the bottom of the "Sandstone" was 1037 feet, and down to that point the dip of the beds was about 1 in 8. The "Sandstone" was found resting uncomformably upon the "Upper Coal Measures Series," as immediately on passing through, a bed of dark grey shale was reached, having a dip of about 1 in 3. All the Measures below this had the same dip. From 1037 feet deep to 1147 feet consisted of a series of dark grey shales and sandstones, and purple shales and sandstones, and then came a grey earthy limestone, 2 feet 4 inches thick. The next 100 feet consisted of purple and variegated shales, with nine beds of limestone, the total thickness of the limestones being 24 feet, besides a bed of limestone breccia 5 feet thick. These are the limestones forming the "Ardwick Series," and by the fracture, &c. Mr. Binney, F.G.S., during a recent visit to the boring, at once recognized them.

At 1265 was a bed of hard purple shale, containing small lenticular nodules of ironstone, the matrixes of which were of yellow earth. From this point to 1300 feet consisted of red and gray sandstone, of very fine grain, with thin beds of shale, and one 9-inch calcareous band of ironstone.

As the distance between the Ardwick limestones and the Openshaw mine is known, the depth to this mine, at the site of the boring, will be about 670 yards.

This borehole has thrown great light on the character of the measures which underlie the "Permian," and also gives some insight into the history of that formation around Manchester.

In endeavouring to construct a section across the rise and dip of the beds from Manchester to Ashton-under-Lyne, I

have availed myself freely of the materials and information given by Mr. Binney, in the several papers read by him before this Society, or before the Literary and Philosophical Society. To his researches in the Manchester district we are very specially indebted.

Commencing at St. Saviour's Church, Chorlton-on-Medlock, and going across the strike of the measures to St. Barnabas' Church, Openshaw, and thence to Charlestown, Oldham Road, Ashton, we find the most clearly-defined member to be the "Permian Marls." These, near Ardwick Station, are 150 feet thick; at the Openshaw borehole, as before named, they are 205 feet thick; whilst going still further north-east, to the Waterhouses in Medlock Vale, they are 245 feet thick.

At the time this member was deposited, the beds undoubtedly occupied one level plain, and the dislocations now apparent must have taken place since the Permian epoch. It is, however, quite clear that as regards one of these faults, viz., that forming the eastern boundary of the "Manchester coal field," and running under St. Barnabas' Church, it must have existed as a large fault prior to the deposit of the Permians, inasmuch as the amount of the displacement of the Permian marls is so much less than the now proved size of the fault. It must, therefore, have existed as a fault of several hundred yards of throw before the marls were laid, and, subsequently to the "Permian" or "New Red" eras, it has been increased to a total downthrow of close upon 800 yards.

The part between St. Saviour's Church and St. Barnabas' Church must, at the beginning of the "Permian epoch," have been dry land; but, at the latter point, the fault then existing would have left a huge cliff facing eastwards, and towering high above the waters of the sea at its base. This sea must have extended eastwards to or beyond Ashton, but

would appear to have decreased in depth towards Ashton, as the thickness of the "sandstone" there is 300 feet less than at the borehole in Openshaw.

By the time the upper portion of the Permian sandstone was deposited, the land now forming the city of Manchester and far away westwards had also sunk and become submerged, so that some 20 to 60 or 80 feet of the sandstone had also been deposited there.

Then, over a wide and still area, the Permian marls were slowly deposited, whilst the land, always changing, settled down more slowly at Manchester than at Ashton, causing a deposit of 151 feet near the Ardwick Station, 205 feet at the borehole, and 245 feet at Waterhouses, near Ashton.

It is highly probable that the coal measures extended unbrokenly under the "Permians," from the large fault at St. Barnabas' Church, to the end of the section shown herewith, at Ashton. If so, then the amount of the dislocations, which the "Permian Marls" have since suffered, will indicate very nearly the actual sizes of the faults in the coal measures at the points where such faults now exist. The positions of some of these faults are not clearly known as yet. At Clayton Bridge the Permian Sandstone was found to be 59 yards to its base, with purple shales underlying. It would appear, therefore, that no fault of any magnitude is likely to exist between St. Barnabas Church and that point. Further east, however, the "Permian Marls" come in again at the surface, and there must consequently be a large fault or faults between Clayton Bridge and there.

At Waterhouses, the "Marls" are again in, so that again there must be a downthrow to the east, between the last named place and Ashton.

Considering this section carefully, it is clear that on the easterly side of the Manchester coal field there are also

stored up immense resources, which will eventually come in for the supply of Manchester. It is true most of the mines will lie at considerable depths, but, as is well known to all present, depths which some years ago were deemed most formidable are now by Mining Engineers thought little of.

In concluding, I have the pleasure on behalf of Mr. Bradbury of the Clayton Collieries, and, at his request, to present a section of the Openshaw borehole for the acceptance of this Society.

Section of Strata passed through at the Bore hole close to the Township boundary between Clayton and Openshaw, and about 100 yards west of the Manchester and Stockport Canal.

Presented by Mr. JOHN BRADBURY.

			Depth from Surface.	
	Ft.	In.	Ft.	In.
DRIFT.				
Soil and sand	5	0	5	0
Large pebbles and sandy clay	2	0	7	0
Brown sandy clay	8	0	15	0
Brown clay	18	0	33	0
Grayelly clay	2	0	35	0
„ and pebbles	1	0	36	0
BUNTER SANDSTONE.				
Red sandstone, soft and very red	40	0	76	0
Red shale	6	0	82	0
Coarse red sandstone, with small white quartz pebbles (size of large pin heads)	0	2	82	2
PERMIAN MARLS.				
Red shale	7	10	90	0
Yellow sandstone	0	6	90	6

			Depth from Surface.	
	Ft.	In.	Ft.	In.
Red Shale, soft, unfossiliferous	12	0	102	6
Yellow sandstone	0	4	102	10
Red shale, no fossils	5	8	108	6
„ „	9	8	118	2
Red sandstone	2	0	120	2
Red shale, no fossils	4	8	124	10
„ „	21	2	146	0
Grey sandstone	0	4	146	4
Red sandy shale	1	2	147	6
Red sandstone, very fine	2	6	150	0
Limestone	0	2	150	2
Grey sandstone, soft	1	4	151	6
Red sandy shale	8	0	159	6
Grey sandstone	0	6	160	0
Red shale	3	0	163	0
Red sandstone, with thin bands of shale	17	0	180	0
Red sandstone	2	3	182	3
Red shale	2	6	184	9
Red sandstone	4	6	189	3
Red shale	6	9	196	0
Red sandstone	4	4	200	4
Red shale	17	0	217	4
Brown limestone, with shells	1	4	218	8
Red shale	2	2	220	10
Layer of gypsum	0	1	220	11
Red shale, 6 in., full of mussel-like bivalves, small	2	5	223	4
Red shale, with shells, and also largish nodules of gypsum	11	0	234	4
Red shale, with rather large shells	5	3	239	6

			Depth from Surface.	
	Ft.	In.	Ft.	In.
Red Shale, soft, unfossiliferous	12	0	102	6
Yellow sandstone	0	4	102	10
Red shale, no fossils	5	8	108	6
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Red sandstone, very fine	2	6	150	0
Limestone	0	2	150	2
Grey sandstone, soft	1	4	151	6
Red sandy shale	8	0	159	6
Grey sandstone	0	6	160	0
Red shale	3	0	163	0
Red sandstone, with thin bands of shale	17	0	180	0
Red sandstone	2	3	182	3
Red shale	2	6	184	9
Red sandstone	4	6	189	3
Red shale	6	9	196	0
Red sandstone	4	4	200	4
Red shale	17	0	217	4
Brown limestone, with shells	1	4	218	8
Red shale	2	2	220	10
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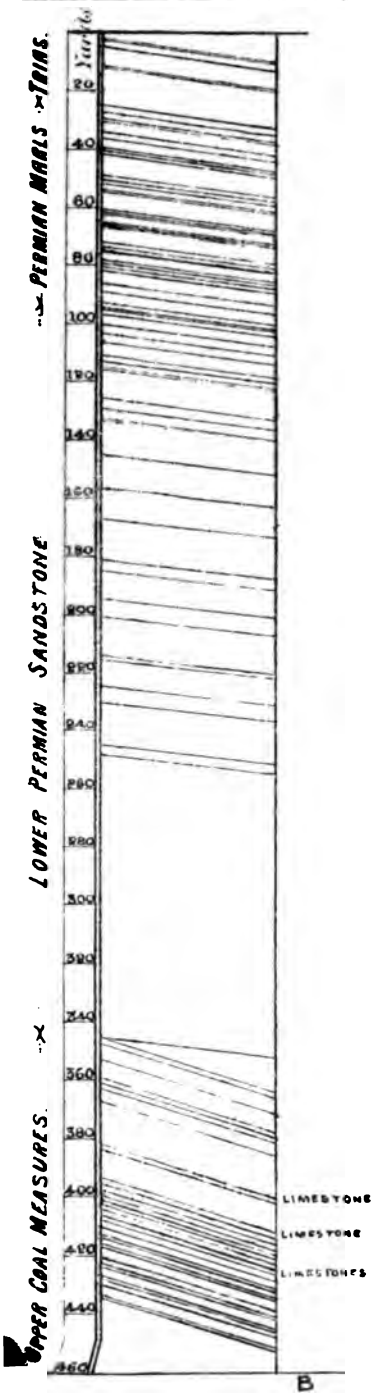
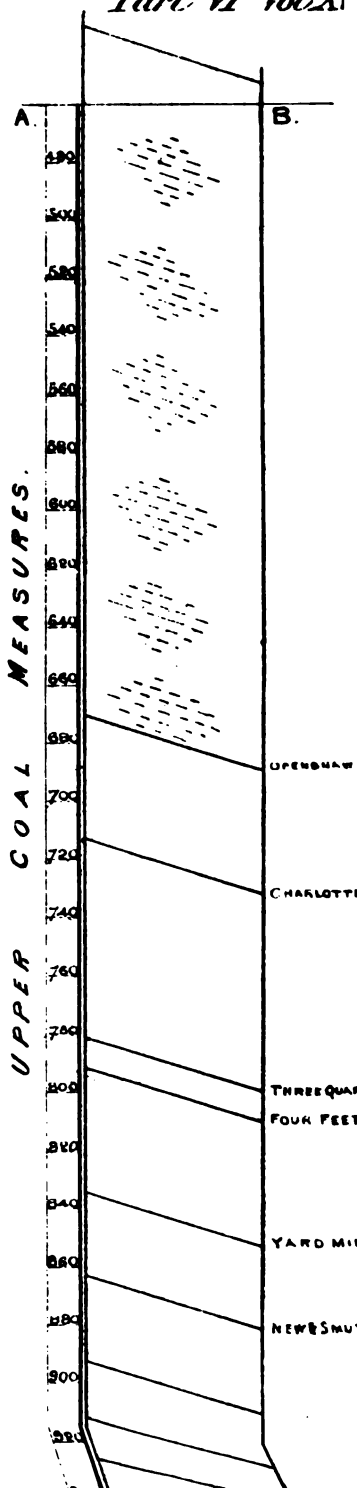
Section of Boring

— AT —

OPENSHAW near MANCHESTER.





			Depth from Surface.	
	Ft.	In.	Ft.	In.
l grey shelly limestone, con- odules of gypsum, with layers ale, concretionary	4	0	243	6
full of shells	1	0	244	6
tone	0	4	244	10
with thin bands, full of shells	12	8	257	6
, with shells	0	6	258	0
with many thin bands, full of	9	0	267	0
own massive limestone, without	0	3	267	3
with some shells	11	9	279	0
with a few thin bands of brown lstone and shells	3	0	282	0
grey sandstone	0	9	282	9
conglomerate	2	3	285	0
PERMIAN SANDSTONE.				
tone, fine and soft	7	6	292	6
one, coarse	9	0	301	6
one, very soft, no core	8	6	310	0
tone, rather coarse	9	6	319	6
tone, soft and full of joints or water went all way, and the sand washed with it	14	0	333	6
one	6	0	339	6
one, finer, with thin beds of shale	5	6	345	0
rey sandstone, fine and mottled, in beds of shale	2	0	347	0
slightly mottled with grey) sand- ne	28	0	375	0
tone, coarser	11	6	386	6
coarse	11	6	398	0
very coarse	37	6	435	6

			Depth from Surface.	
	Ft.	In.	Ft.	In.
Red sandstone, rather coarse	35	0	470	6
„ finer grain	29	0	499	6
„ „ with beds of coarse.	42	6	542	0
„ „ „ „	12	0	554	0
„ a little coarser	29	6	583	6
„ „ harder	17	8	601	2
„ „ softer	41	7	642	9
„ mottled	1	6	644	3
„ red and soft	29	3	673	6
„ very soft and fine grained.	17	6	691	0
„ coarser	42	0	733	0
„ stronger	12	0	745	0
„ soft	291	6	1036	6
„ „	0	6	1037	0
UPPER COAL MEASURES.				
Dark grey shale	5	0	1042	0
Dark grey gritty shale, with bands of purple shale (dip about 1 in 3)	16	0	1058	0
Purple shale	17	0	1075	0
Dark grey shale, rather gritty	5	0	1080	0
Grey sandstone	0	6	1080	6
Purple shale	3	6	1084	0
Dark grey and purple sandy shale	4	0	1088	0
„ „ sandstone	13	0	1101	0
Purple shale, very dark purple	46	6	1147	7
Grey earthy limestone	2	4	1149	11
Grey shale	0	2	1150	1
Purple shale	27	1	1177	2
Grey limestone	9	4	1186	6
Purple shale, with green shale	6	0	1192	6
Grey limestone	1	8	1194	2
Grey and purple shale	1	10	1196	0

			Depth from Surface.	
	Ft.	In.	Ft.	In.
Purple shale	0	4	1196	4
Brown limestone	2	8	1199	0
Purple shale	1	8	1200	8
Grey limestone	4	4	1205	0
Purple shale	9	4	1214	4
Red shale and limestone breccia	5	0	1219	4
Variegated shale	5	0	1224	4
Limestone breccia	0	6	1224	10
Red shale	5	6	1230	4
Limestone, earthy	1	10	1232	2
Variegated shaley clay	5	0	1237	2
Grey limestone	0	6	1237	8
Shale	0	6	1238	2
Grey limestone	1	6	1239	8
Purple shale	1	6	1241	2
Limestone	0	9	1241	11
Shale	0	3	1242	2
Grey limestone	1	6	1243	8
Shale and clay	4	6	1248	2
Variegated shale, principally purple towards bottom	11	6	1259	8
Purple shale, containing small benticular nodules of ironstone with yellow earthly matrix	5	8	1265	2
Red sandstone, very fine	1	0	1266	2
Red and grey, very fine	11	4	1277	6
Purple shale	3	3	1280	9
Calcarcous band, with ironstone	0	9	1281	6
Sandstone and shale, &c. (only 2 ft. of core out of 7ft. 6in.)	8	0	1289	6
Red and grey sandstone, fine grained, with fossil fern (Neuropteris), thin beds of shale	9	6	1299	0
Red shale	1	0	1300	0

The CHAIRMAN said he was sure that all the Members must feel obliged, both to Mr. Bradbury for the section and to Mr. Atherton for his valuable communication. Mr. Atherton was so kind as to take him, a few weeks since, to see all the cores, and, as he (Mr. Atherton) stated, there could be no doubt whatever as to these limestones being the same as those wrought at Ardwick. The subject was one of very great importance, and one on which he had laboured for over forty years. It had often struck him whether the fault east of the Manchester coal field was one great fault, or whether there were two or three steps between there and Waterhouses. On the south-west side of Manchester—underneath the sugar works in Chester Street—the Ardwick limestones, as they all knew, were again met with. Mr. Atherton had stated that this was the thickest of the Permian sandstones that had been met with in the neighbourhood. He (Mr. Binney) thought, however, that the lower Permian sandstone was to be found very thick indeed. Certainly, in the neighbourhood of Stockport, they had bored considerably over four hundred feet without getting through it. But when they came to Manchester, on the south of the town, it was scarcely found at all. Its occurrence was very variable. The ground between Waterhouses, where the measures were well seen, and Bradford admitted of any amount of discussion, and he did not know that it had been ventilated much for the last thirty years, except by the Ordnance Survey. The late Mr. John Wood made two or three very interesting borings in Medlock Vale, and they confirmed those of Mr. Atherton to a few feet. They really might have been the same, except that Mr. Wood found no Ardwick limestones. He, however, met with coal measures, immediately under the Permian beds, with plenty of *Stigmaria* rootlets and a little coal seam.

Mr. DICKINSON said that during the time that the Society met at the Museum, in Peter Street, they had a section of Mr. Wood's bore-hole hanging upon the wall. He did not know what had become of it, and he thought that a copy of it and of some others presented by Mr. Binney should be inserted in the Transactions. There was one thing apparently not noticed by Mr. Atherton, which he would like to name. It was possible, when the measures came to be worked, that those large bore-holes, through the water-bearing strata, might form channels for the influx of water. He named this to Mr. Bradbury's manager, and that gentleman undertook to have the hole in question thoroughly plugged. For fifty yards from the bottom he had had strong clay put in and pressed down as far as could be conveniently done with the rods.

The CHAIRMAN said that if Mr. Livesey could furnish some information with regard to their sinking, it would be of great value.

Mr. LIVESEY said that a section was now being prepared for the Society.

The CHAIRMAN: Then we could really have a discussion whether the 4ft. coal of Bradford is the same as the 4ft. of Pendleton. It had always been taken for granted, but certainly never positively proved, although the red ironstone of Patricroft and that under the Beswick Brewery were very much alike.

Mr. DICKINSON said that for many years it had been taken for granted that the 4ft. of Worsley and Pendlebury was the 4ft. of Bradford. But in preparing the quantities of coal for the Coal Commission he went very closely into that matter, and from information which he had derived from Mr. Livesey's bore-hole, he concluded that that idea would have to be given up; and he thought when Mr. Livesey

put his section before the Society, they would find that although the position was an old-accepted one, it was not sound.

Mr. LIVESEY said he had been engaged in mining in the district of Bradford now for twenty-five years, and the more he came to consider it the more he got into confusion. He felt very certain, when he began, that the Bradford 4ft. was the same as the Worsley 4ft., but he was now convinced that he knew nothing about it. Mr. Atherton had been so good as to say that the new mine they (Messrs. Livesey) were working was the one immediately over the big mine at Ashton, but they had bored to a considerable depth below it, and he thought Mr. Atherton's conclusion was highly improbable.

Mr. DICKINSON said there was another interesting sinking being put down this side of Ashton-under-Lyne, which penetrated many hundred yards into those top measures, and might throw some further light upon the question. He hoped Mr. Higson would favour the Society with a copy of that section.

Mr. PLANT said he never believed that the 4-feet mine of Bradford was at all equivalent to that lying on the west side of Manchester. Several fossil fishes occurred in the Bradford shales, of which not a fragment, up to the present time, had been found either in the Pendlebury, Clifton, or any of the mines lying to the west; he had arrived at the conclusion that there were but few evidences of identity between the two series of beds of coal and shales.

The CHAIRMAN said that in former times—that was, before the 4-feet was drowned out—fish were plentiful at Pendleton. He had had such good luck as to get two or three entire fishes in a day. That was forty years ago; but since then he had not had a chance of getting

fishes from the 4-feet mine on the west side of Manchester.

Mr. PLANT said there were marked differences between the fishes in the shales of the west and those of the east of Manchester. At Bradford they were small, whilst the specimens from the west of Manchester were much larger, and belonged to entirely different genera.

The CHAIRMAN said the largest tooth he ever obtained was at Pendleton: it was a triturating tooth, and the largest he ever saw in this district. He had had a collection of his own once at the Royal Institution; but had never seen many specimens from Pendleton in the Museum of this society.

Mr. PLANT: All I have seen from the two localities are distinct in their characters.

The CHAIRMAN: Fish are very good in their way, but they are not everything, for identifying seams of coal. I have heard people say that they can identify a seam by a scale, as they can identify a fish by a scale; but I do not believe it. The greatest living palæontologist can't do it. I remember one of our celebrated men being puzzled by a man who, when I used to go "fishing" at Pendleton, made baskets there, but he afterwards took to collecting fish, and made a fine collection. Several of his specimens were sent to a great man, who made as many genera out of them. The fact, however, was that the basket maker had taken them all from one fish. Depend upon it, we must have some good practical sinkings or borings, as well as fish, to guide us.

Mr. PLANT: The fishes I have are almost perfect specimens.

The CHAIRMAN: If we could prove the identity of these

beds either by fish, flesh, or fowl, it would be very desirable, and I hope when Mr. Livesey brings his paper we shall have a full discussion and expression of opinion on the subject.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VII. VOL. XV. SESSION 1878-9.

An ORDINARY MEETING of the Members of the Society was held on Tuesday, the 29th April, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

E. W. BINNEY, Esq., F.R.S., Vice-President, in the Chair.

Lord Lindsay, F.R.S., M.P., 47, Brook Street, London, W.; Mr. Arnold Lupton, M.I.C.E., F.G.S., Cross Gates, near Leeds; Mr. John Walshaw, Colliery Manager, Tyldesley, were elected ordinary members of the Society.

SECTION OF STRATA AT BRADFORD COLLIERY.

BY MR. CLEGG LIVESEY.

The Manchester coal field has been worked for the supply of Manchester for more than 150 years by the Bradford Colliery Co. and its predecessors, who have during that time held leases of the central portion. More recently the extreme westerly part was wrought by the late Mr. Edmund Buckley, at St. George's Colliery; and the eastern side, under portions of Bradford, Clayton, and Openshaw, by the Clayton Colliery Co.

It might reasonably have been expected, therefore, that the exact position of the coal field, with all its characteristics

and surroundings, would have been thoroughly ascertained. But it must be remembered that in former times few notes were made of established facts, and still more rarely were proper plans and sections made. So that although there has long existed a belief that the mine known as the Bradford Four-feet is the same as the Four-feet at Worsley and Patricroft, and there are traditions of various attempts having been made to prove if this is so, yet no record of any such explorations have been preserved.

This Society has already a very good section of the well-known upper seams in this district, viz., the Openshaw, Charlotte, Three-quarters, Four-feet, Yard, and Two-feet. The first effort to penetrate below these, of which the present Bradford Colliery Co. have any actual knowledge, was made by the late Mr. Porter, who had a hole put down near the Old King's Arms Inn, on the Oldham-road. (Marked No. 1 on the Geological Map). This hole, after passing through the drift, went into a very red and hard sandstone, boring through which was so expensive, and the progress so slow, that after reaching a depth of about 50 yards from the surface the attempt was abandoned. Mr. Porter was of opinion that this rock was the New Red Sandstone, and similar in all respects to the sandstone at Bank Bridge Print works.

In June, 1856, the Company commenced sinking a shaft in order to prove whether the Four-feet Mine was, as had been commonly reported, the "Worsley Four-feet Mine" of the west side of Manchester. The site of this shaft (marked No. 2), was in the township of Manchester, at the top of Bradford Road, and near to where the new cemetery now is. In this shaft the Four-feet was passed through at a depth of 37 yards, the Yard Mine 70 yards, and the Two-feet Mine 138 yards. It was supposed that the Crombouke series of mines would lie about 300 yards under the Four-

feet, and when we reached a very hard sandstone, with numerous balls of per-oxide of iron, at a depth of 280 yards from the surface, containing a large feeder of water, it was thought advisable to put down a bore-hole to ascertain what further distance we had to sink. (I may here say that we found this rock was the same as the one Mr. Porter had mistaken for the New Red Sandstone, and was also the same as that from which the Newton Heath brewery drew its water supply.)

To our disappointment, in boring to a depth of 290 yards below the bottom of the pit, or 533 yards below the Four-feet Mine, we found no workable seam ; the only one worthy of the least attention being at a depth of 429 yards below the Four-feet, and of a thickness of 2ft. 6in. This mine is the one we have now sunk to in Bradford, and have named, after the owner of that township, the "Parker" Mine. As this seam would only have been about 2ft. 3in., measuring the thickness at right angles to the floor, we did not look upon it as warranting any further outlay, and after reaching the depth of 570 yards from the surface, we ceased work.

Encouraged by the fact that the red rock we had passed was the same Mr. Porter had bored in, we next commenced a bore-hole (No. 3) in Newton Heath, thinking we might probably get into the lower measures to the rise. Here again we were disappointed, as not only at No. 3, but also at No. 4, we came into what was undoubtedly the New Red Sandstone, as soon as we had passed through the drift.

It is not necessary to mention all the trials we made betwixt these holes and our most westerly attempt in Messrs. Derbyshire's fire-brick yard, just below Queen's Park. The result, however, was that we had already bored at the pit to a greater depth than we could hope to reach at any of these places, by the then ordinary means.

At the commencement of the year 1866, the owner of the

township of Bradford, R. T. Parker, Esq., having agreed to join with the Company in another attempt to discover what mines underlie those being worked on his property, a small trial shaft was commenced in the said township, and was carried down to a depth below the Four-feet of 434 yards; but not being satisfied with the rate of progress that so narrow a pit could make, we contracted with the Diamond Rock Boring Co. to complete the work. After boring eight yards they cut through the Parker Mine before named, but here the thickness was 3ft. 2in. at right angles to the floor, and the pit of which the annexed is a section has since been sunk to it. The boring was continued to a depth of 157 yards below the Parker Mine, and this part of the section is given from the cores brought up.

I may here mention a curious fact about this coal field. All the mines are very considerably thicker on the east than on the west. Seams that, in former times, were considered workable at Clayton, were only a few inches thick near Miles Platting. The Yard Mine has been quite a good workable coal near to the east fault, whilst on the west side of Bradford it is too thin to be worthy of notice, and of very inferior quality. We find the same state of things in the Parker Mine. As I have before stated, at the place marked No. 2, it was found only 2ft. 6in. in vertical thickness, and when we found that it was 3ft. 6in. in vertical thickness, we concluded that some mistake had been made; but, unfortunately, it is following the rule I have mentioned. As our driving proceeds westwards, we find the seam divided in two by a strong band of stone, about a foot from the bottom, and this is gradually running the lower part out. It is, therefore, extremely probable that only a very small extent will be workable, as compared with the whole coal-field, and that the value of the discovery of this Mine is *nil*, so far as regards the lower portion of Newton Heath and all beyond.

There is another curious fact that I wish to notice. None of the sections agree, and it has been with the greatest difficulty that anything like a comparison could be made between the boring or sinking at one place, and that at another. So marked is this that although the trial shaft at Bradford is only 26 yards from the new winding shaft, we often found it impossible from comparing the strata in the two pits, to tell with sufficient accuracy where we could make through-drifts for airing purposes, to meet each other, when commencing one end in each pit.

In conclusion, I may say that this sinking has clearly proved that there exists no seam of workable thickness and quality between the Four Feet Mine, and the new or Parker Mine, and that there is no workable seam for a distance of 157 yards below the latter.

It will be very clear that this does not correspond in the least with the section underlying the Worsley Four Feet in any portion of the district west of Manchester, and, therefore, the question whether the Bradford Four Feet is identical with it, remains still as far from solution as ever.

	Yds.	ft.	in.
Clay and marl, with boulders	16	0	0
	0	2	0
	0	0	4
Do. *with coal*	1	0	5
Strata of which no particulars were kept.. ..	24	0	4
Rock bands	1	1	6
Strong metal	6	2	4
Black shale	1	1	10
Soft floor dirt	2	0	4
Strata of which no particulars were kept	33	2	0
Coal ¾ mine	0	1	7½
Strata of which no particulars were kept.. ..	20	2	1

	Yds.	ft.	in.
Cannel	0	0	9
Four feet coal	1	1	0
Blue metal	11	1	4
Strata of which no particulars were kept	23	1	10
Yard mine	1	1	1
Strata of which no particulars were kept	11	0	2
Smut coal	0	0	11
Floor dirt	1	0	6
Grey stone	0	2	4
Blue shale	1	0	0
Rock	1	2	10
Blue shale	5	0	3
Cannel	0	0	7
Coal	0	0	11
Floor dirt	0	0	1
Rock	1	1	6
Blue shale	0	0	4
Rock	0	2	2
Blue shale	0	1	10
Black bass	0	1	2
Floor dirt	0	1	9
Rock	0	1	3
Blue shale	0	0	1
Rock	1	0	5
Blue stone	0	1	3
Grey stone	0	1	0
Rock bands	0	1	6
Grey stone	3	0	0
Blue shale	1	1	6
Bass	0	0	1½
Floor dirt	1	1	6
Burr	0	2	4
Floor dirt	0	1	6

	Yds.	ft.	in.
Blue shale	1	0	3
Black bass	0	0	10
Floor dirt	1	0	10
Rock bands	0	1	10
Blue shale	2	1	3
Black bass	0	0	9
Floor dirt	0	2	6
Rock	1	0	0
Floor dirt	1	2	0
Grey stone	5	0	0
Bass	0	1	5
Floor dirt	0	1	0
Rock bands	1	0	2
Grey stone	2	2	9
Bass	0	0	6
Floor dirt	0	2	1
Coal	0	1	6
Floor dirt	0	0	6
Bass	0	0	2
Floor dirt	1	1	10
Grey stone	3	0	2
Rock	0	2	0
Grey stone	0	2	6
Blue shale	1	2	0
Ironstone	0	0	1
Blue shale	2	1	2
Black shale	0	2	2
Coal (two feet mine)	0	1	7
Bass	0	0	0½
Floor dirt	0	2	4
Bass and coal	0	2	7
Floor dirt	0	1	4
Bass	0	0	3

	Yds.	ft.	in.
Floor dirt	0	1	8
Rock bands	2	2	0
Grey stone	1	2	2
Blue shale with iron bands	1	2	9
Coal	0	0	11
Floor dirt with hard balls of limestone	2	0	9
Grey stone	2	2	0
Blue shale	1	2	7
Coal	0	0	9
Floor dirt	2	1	0
Blue shale	0	1	7
Black bass	0	0	2
Coal	0	0	6
Bass	0	0	0½
Floor dirt	0	1	3
Rock	3	2	4½
Grey stone	1	1	8
Black shale	0	0	3
Coal and bass	0	0	2
Floor dirt	0	2	11
Rock	3	0	5
Rock, very hard	2	0	5
Grey stone	1	1	2
Rock	0	1	2
Grey stone	0	1	2
Blue shale	2	2	3
Black shale	1	2	0
Blue shale	1	2	10
Coal	0	0	6
Floor dirt	1	1	3
Bastard coal	0	0	6
Floor dirt	4	0	1
Black shale	0	0	2

	Yds.	ft.	in.
Coal	0	0	2
Floor dirt with iron nodules	1	1	2
Dark shale	2	0	8
Coal and bass	0	0	6
Floor dirt	2	0	3
Linsey	2	1	2
Blue shale with ironstone bands	1	2	0
Black stone	2	0	10
Rock....	5	0	5
Linsey	8	1	5
Blue shale	6	0	0
Coal	0	0	3½
Floor dirt	0	2	0
Rock	2	0	0
Linsey	0	1	0
Black shale	0	0	6
Floor dirt	0	2	6
Rock	3	2	0
Blue shale	2	1	0
Rock, very hard	0	2	6
Dark shale	1	1	0
Rock (flaggy)	1	0	0
Dark linsey	1	1	6
Dark shale and ironstone bands	7	0	0
Black stone	0	1	6
Floor dirt.....	1	0	6
Floor black	1	0	0
Blue metal with iron bands	2	1	0
Black shale do.....	4	1	0
Floor dirt	0	1	6
	325	1	9
Deduct for stretching of rope in boring ...	0	1	6
	325	0	3

	Yds.	ft.	in.
Rock	2	0	0
Linsey	2	1	0
Blue metal	1	0	0
Dark shale	1	1	2
Coal	0	0	5
Bastard cannel	0	1	4
Floor dirt...	1	0	0
Grey stone	4	2	6
Black stone	0	2	9
Rock	2	1	6
Linsey or rock bands	9	0	0
Blue metal with iron bands	3	0	0
Black shale	2	2	0
Floor dirt	0	1	9
Coal	4	1	6
Bass with streaks of coal	0	0	6
Floor dirt...	1	0	0
Rock	1	2	6
Flaggy rock	8	1	6
Coal	0	2	2
Black floor dirt	1	1	0
Floor dirt	3	1	0
Rock	1	1	6
Floor dirt	6	1	0
Coal	0	0	1
Black bass on floor dirt	0	1	6
Floor dirt...	0	2	0
Rock, red and white layers	24	0	0
Metal	1	0	0
Rock	9	0	0
Metal	1	0	9
Rock	1	2	0
Metal	1	1	0

	Yds.	ft.	in.
Dark metal with iron bands...	0	0	2
Black bass	0	2	0
Floor dirt	0	1	0
Ironstone bands mixed with shale	0	2	6
Floor dirt	1	0	4
Coal and bars	0	1	4
Cannel	0	2	0
Rock bands or flaggy rock	10	0	0
Blue metal with iron bands and nuts	2	1	6
Coal	0	0	8
Metal	5	0	0
Rock bands	0	1	6
Metal	1	1	9
Rock bands	0	1	0
Metal with ironstone bands	10	0	0
Black shale with ironstone bands	1	0	9
Floor dirt	7	0	0
Metal	3	2	0
Black shale	1	0	0
Rock bands	5	1	0
Metal	2	1	0
Metal black	0	2	6
Do.	1	1	6
Do.	1	1	2
Cannel	0	0	4
Coal	0	0	5
Floor	1	0	0
Metal	2	2	0
Black shale with iron bands...	0	1	6
Coal with 2in. stone in middle	0	1	9
Floor dirt	1	1	6
Rock	6	0	0
Metal	1	0	6

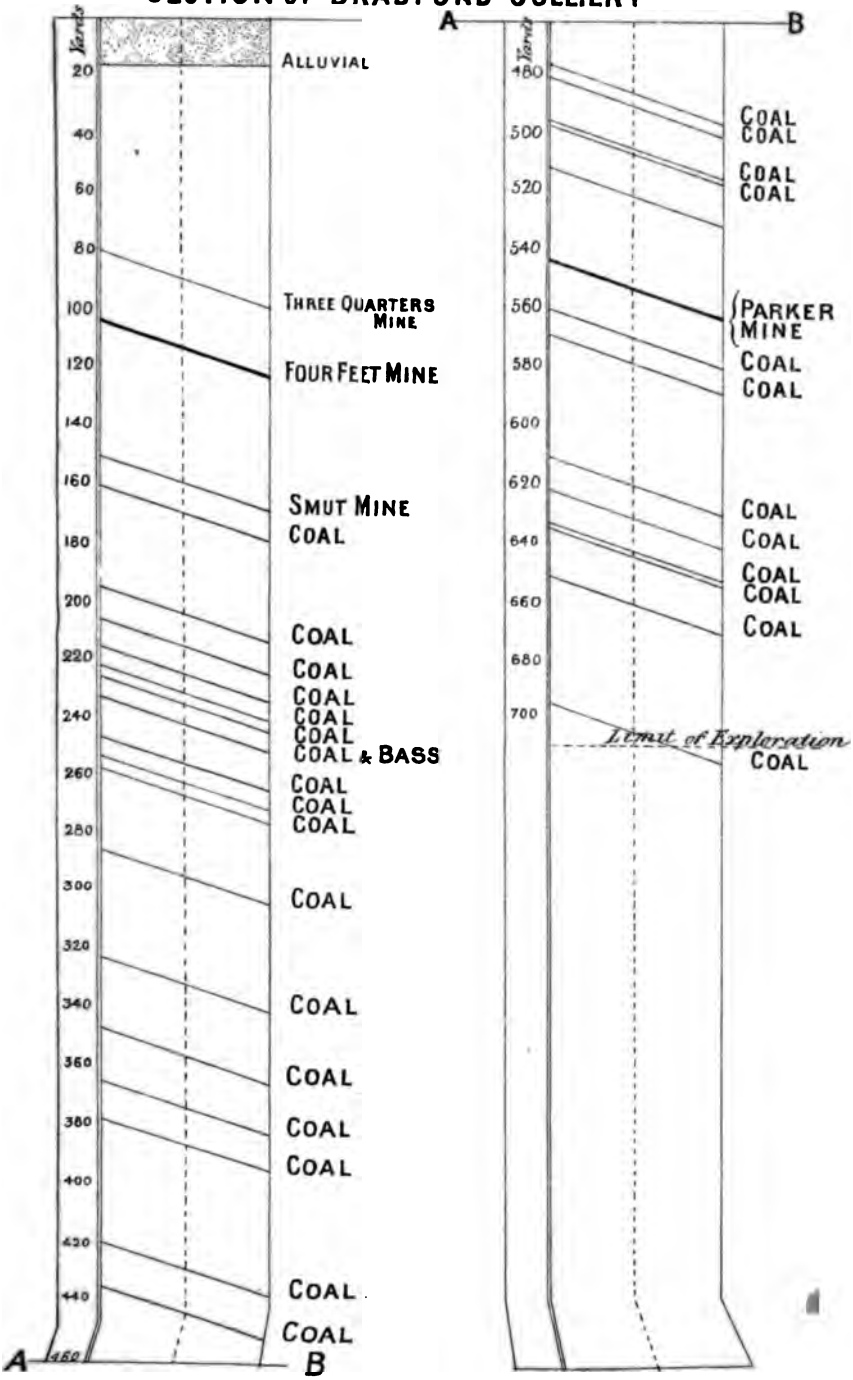
	Yds.	ft.	in.
Black shale	**0**	**2**	**2**
Floor dirt	**2**	**1**	**0**
Rock	**1**	**1**	**6**
Metal	**0**	**2**	**3**
Coal	**0**	**0**	**9**
Floor dirt	**0**	**1**	**0**
Coal and bass	**0**	**0**	**9**
Rock	**4**	**0**	**0**
Metal	**4**	**1**	**4**
Black stone	**0**	**2**	**6**
Strong metal	**0**	**2**	**4**
Rock	**3**	**2**	**6**
Metal with iron bands	**1**	**0**	**10**
Coal	**0**	**0**	**4**
Floor dirt	1	2	0
Rock (September 25th)	5	0	6
Metal	4	2	6
Black shale	0	1	8
Metal	0	2	0
Floor dirt	2	0	9
Metal	1	0	0
Bass	0	0	6
Floor dirt...	1	0	6
Metal R.	3	0	0
Black shale	0	0	6
Floor dirt	1	0	6
Flaggy rock	6	1	7
Grey metal	1	2	9
Coal and dirt (Parker Mine)	0	3	6¼
Floor dirt	1	2	9½
Rock	7	1	0¼
Metal	4	0	10¼
Rock	1	1	9

	Yds.	ft.	in.
Metal	0	2	5¾
Coal	0	0	8½
Metal	9	0	1
Do.	1	1	3
Coal and dirt	0	0	7
Metal	1	0	4
Grey metal	5	0	1
Rock	27	0	1
Metal	8	2	2
Coal and dirt	0	1	10
Metal	1	0	0
Do.	8	0	8½
Coal and dirt	0	0	10
Metal	1	0	5½
Rock	10	0	4
Coal and dirt	0	0	8
Metal	0	0	5
Coel	0	1	9
Rock	9	2	1
Coal and dirt	0	1	6½
Metal	6	0	9½
Coal and dirt	0	1	0
Floor dirt	0	0	9
Metal	1	0	8
Rock	6	2	2
Metal	1	2	4
Do.	3	1	5½
Floor dirt...	0	1	7
Black bass	0	1	1
Metal	1	0	3
Rock	4	0	6
Metal	8	0	8
Rock	3	2	8

	Yds.	ft.	in.
Metal	7	0	0
Rock	3	1	2
Metal	1	1	2
Coal	0	0	5
Black bass	0	1	2
Floor dirt	4	1	11
TOTAL	707	0	5

The CHAIRMAN said that the section presented by Mr. Livesey was one, which, he had no doubt, would give rise to a very interesting discussion. It was a section in perfectly new ground, so far as his knowledge extended. He might state that the opinion of all geologists, up to 40 years ago, was that the 4ft. seams at Bradford and Pendleton were identical; of course, there was no chance of proving it by continuity, and whether it was merely from the thickness of the seams that they were called the 4ft., or from some other cause, he was not able to say. It was in the year 1835 he first looked at a section of the Manchester coal-field. The Medlock was then in a very different state to what it is now, and a section could be pretty well seen to the 4ft. seam, and to probably 100 yards below it. The evidence on which he first tried to get a connection between the Pendleton 4ft. and the Bradford 4ft., was in the sinking of a shaft at Patricroft. Messrs. Lancaster's having seen a small coal at Slack Lane, near Patricroft, thought that they had got the Pendleton yard coal, and at a depth of 80 yards below it they would get the 4ft. Calculating upon having a good and extensive field, they sank a pit not very far from the Patricroft Railway Station, but instead of finding the 4ft. coal at a depth of 80 yards they sank to above 380 without finding it. He observed a good deal of their sinking, and they

SECTION OF BRADFORD COLLIERY



came upon a calcareous ironstone, that calcareous ironstone was a remarkable feature; he had never seen anything like it in the Lancashire coal-field, though he had observed it in Staffordshire and elsewhere. Afterwards he went below the brewery in Beswick, and there, on the banks of the Medlock he dug into a calcareous ironstone, which was like a red hæmatite, and found it similar to that at Patricroft. The bed at Patricroft was about 360 yards above the 4ft. The one at Beswick was somewhere about 350 yards above the 4ft. at Bradford; therefore, seeing those two limestones very much alike, it struck him that the 4ft. of Pendleton and the 4ft. of Bradford might be the same. There were other features about those upper coal-fields, which would probably tend to show some similarity; but the only evidence he ever heard, was that bed of calcareous ironstone. In no part of Lancashire, to the west, had he seen anything like it, probably, because they did not get measures so high, and he might also mention that he heard, many years ago, some report of a limestone having been found at Patricroft similar to the Ardwick limestone, nearer the railway. He could, however, get no direct evidence of it. He asked Mr. Livesey how many seams of coal he found at Bradford between the Four Feet and the Parker Mines. Mr. Livesey said twenty-three. That is remarkable, as the same number of seams were found in Mr. Fitzgerald's pit at Pendleton, between the Four Feet and the Albert Mines. He suggested that when Mr. Livesey's section was published in the Transactions, they would be in a better position to discuss it. He was sure they never could exhaust the subject at one meeting.

DIAGRAM OF THE IRISH PALÆOZOIC ROCKS. SHOWING A NEARLY CONTINUOUS SEQUENCE FROM THE COAL MEASURES TO THE CAMBRIAN.

By G. H. Kinahan, M.R.I.A., President of the Royal Geological Society, Ireland.

In this diagram the thicknesses are probably less than they would be represented by most geologists. They, however, have been calculated with great care, and in all cases where there was possibly a repetition of beds by faults, allowance has been made for this; while in those groups which are of various thicknesses, only the mean thicknesses are given. The thickness of the Lower Cambrian may be excessive, as on account of the nature of the county of Wexford, where they are best developed, no exact calculations can be made. Eruptive rocks that occur at particular zones are represented; they consist of Greissen (quartz-rock), Felstones, and Traps. The Lower Cambrians are found principally in the counties of Dublin, Wicklow, and Wexford, the lowest beds being in the latter county, at Carnsore, the S.E. extremity of Ireland, where they are metamorphosed into granite. Very similar granitic rocks, supposed to be of the same age, also occur at Erris Head, county Mayo, the N.W. extremity of Ireland; and possibly they also occur in the west portion of the county Donegal. But the latter county has still to be worked out.

The Upper Cambrians have only been recognised in the west of the county of Galway, where they extend comformably upwards through a series of rocks (Great Micalyte and Lettermore Quartzyte series), probably the representatives of the Arenig group, into the Cambro-Silurians.

The lower groups of the Cambro-Silurians (Dark shale and Ballymoney series) are extensively developed, occupying

large tracts in Ulster, Leinster, and Connaught, where they are often more or less metamorphosed. The upper group of the Cambro-Silurians (Upper series) occurs principally in N.E. Munster, having been found in the Slieve-na-man, Galtees, Slieve Muck, Slieve Phelim, Slieve Arra, Slieve Bernagh, and perhaps, also, in Slieve Aughta. Of these the most remarkable locality is Ballycar Cratloe Hills (part of Slieve Bernagh), a little north of the city of Limerick, where a zone containing Silurian fossils (Upper Llandovery) occurs inthe Cambro-Silurians. This seems to prove that between the rocks in this locality and the Silurians of Galway there cannot be a break of magnitude, the thickness of the absent strata probably not exceeding a few hundred feet.

The typical or marine Silurian rocks are thickest in the counties of Galway and Mayo; in the latter county near Ballaghaddereen (Curlew Mountains) they extend upwards conformably into the Dingle or Glengariff beds; but in West Cork and Kerry the passage from the Silurians into the Carboniferous is best developed. To the north of Dingle Bay, in the Dingle Promontory, the Silurians pass conformably upwards into the Dingle beds; but the latter are capped unconformably by the Carboniferous Old Red Sandstone. This, however, is not the case to the south of Dingle Bay, as here (also in the adjoining portion of the County Cork) the Dingle beds pass up conformably into the Carboniferous. From the section between Dingle Bay and Kenmare River we learn that only a few thousand feet of strata are absent in the Dingle promontory, between the Dingle beds and the overlying Carboniferous Old Red Sandstone. The discordancy in the Dingle promontory can be easily explained from the great downthrow to the north of the nearly E. and W. fault along the valley of Dingle Bay; it is, however, unnecessary to enter into this subject here.*

* See Proceedings Royal Dublin Society, Session 1878-79.

There are some remarkable differences between the Irish and English Silurians. In the former in Kerry, Galway, Mayo, and Tyrone (?) there is a zone carrying Cambro-Silurian (Caradoc) fossils, while in some localities the fossils will be Upper Llandovery type, but in other places on the same horizon they will be of Wenlock. A very remarkable fact is that the fossils characteristic of the highest group (Salrock beds) in Galway—that is, in Ireland, if the Dingle beds are not included in the Silurians—are pronounced by Davidson, the eminent Palæontologist, to be of Upper Llandovery types.

The Lower Carboniferous rocks are thickest in Munster. In Cork and the adjoining portion of Kerry they are nearly solely argillaceous and arenaceous rocks, while in Limerick, Clare, Tipperary, also in the provinces of Leinster and Connaught, they are for the most part limestone; but in the province of Ulster, associated with the limestones, are arenaceous and argillaceous rocks, and in one place, Ballycastle, County Antrim, workable coals: the latter apparently on about the same geological horizon as the Lower Coal Measures of Scotland. The Upper Carboniferous, or Coal Measures, occur in all the provinces, capping the different types of the lower. In Clare and Kerry, where they seem to be thickest, they contain the fewest workable seams of coals. In Connaught and Ulster, there are workable coals in the Middle Measures, while in Tyrone the seams are most numerous. In Cork, Limerick, Kerry, Clare, Meath, and Louth, fish remains of true Coal Measure types have been found in the lowest strata of the Coal Measure (Lower Measures.

Professor Boyd Dawkins said he had not had any opportunity of studying the sections described by Mr. Kinahan, but one reflection occurred to him in looking at what was now shown to them, namely, that they found the Carboniferous plants descending considerably below the

Carboniferous rocks in England. With regard to the controversy as to the existence of the Devonian rocks as a formation or not, it seemed to him that the proper view to take was, that the flora did not tell us anything whatever with regard to the classification of Devonian and Carboniferous, or even Silurian strata. As a matter of fact, when we looked at the changes which were offered by the fossil floras all over the world, we found that the flora was invariably changed much more slowly than the animal life; so that we had, for example, in the Cretaceous age of America a group of plants which for a long time were considered to be of Meiocene age in Europe. It seemed to him, therefore, in the controversy as to the Devonian being Carboniferous or not, that the fact of finding *sigillariæ*, *stigmariæ*, and the like in Devonian rocks did not settle the question at all. So far as he knew the evidence of the palæozoic flora, those trees which arrived at their maximum development in the Carboniferous age, and which were taken to be distinctly of the Carboniferous flora, had their origin in the Upper Silurian times. During the time when the Silurian rocks of this country were being accumulated under the waves of the sea, there were on the land forests in all probability closely allied to those which afterwards flourished on the land in the Carboniferous age; therefore the occurrence of Carboniferous plants in the Devonian did not really tell them that the latter beds were of true Carboniferous age, using it in the sense in which the term "Carboniferous period" had been used as far as relates to England. He merely mentioned this because, in the discussion on this matter, the difference in the value of the evidence of fossil vegetables, as compared with the higher existences—that is to say, the animals—had not, to his mind, been properly realised.

Mr. JOHN AITKEN said that Mr. Kinahan, in the paper, made use of the term "Carboniferous old red." He did not

know the meaning of this, unless it applied to those disputed beds which some claimed as Carboniferous and others as Devonian, or old red.

The CHAIRMAN: It is new also to me.

Mr. DE RANCE said that so far as he understood Mr. Kinahan's views, from his published papers, he (Mr. Kinahan) maintained that the Dingle beds and Glengariff grits of the south-west of Ireland were equivalent in time, and that they were Upper Silurian. In the Dingle district they had resting upon them certain beds which, according to the Geological Survey, were Old Red, and, according to Mr. Kinahan, were Carboniferous; but he made that a minor point. He thought the author merely meant by "Carboniferous old red"—the red and sandy condition of the base of the Carboniferous of that particular area; and to that particular horizon he referred the Kiltorkin beds in Kilkenny and the middle districts of Ireland, which contained the *Cyclopteris* (or *Palæopteris*) *Hibernicus*. That plant, according to Mr. Kinahan, marked the base of the Carboniferous series, and that agreed with the conclusions of Prof. Heer, in the work in which he showed the arrival of the *Ursa* stage to be equivalent to the Lower Carboniferous formations of this country. The *Ursa* stage of Iceland and Spitzbergen contained the same plants; and Prof. Heer compared it to the base of the Carboniferous, laying great stress on the fact that the first rich land-flora the world ever saw came into being before the Carboniferous Limestone, and that that same flora—a Carboniferous flora—existed on and on throughout the whole time occupied by the deposition of the Carboniferous limestone in various parts of the world, and up and into our coal measures. The great point of difference between Mr. Kinahan and Mr. Hull on the Devonian question, appeared to be with regard to the beds near the Kenmare river. In the Dingle district there appeared not

to be much in dispute; they had at the base beds of Carboniferous age—call them old red, if they liked—resting on the Dingle beds, which were Upper Silurian. Then, coming further south, to the Kenmare river, Mr. Kinahan said: "Here we have conformity, with a perfect transition from the Carboniferous old red, down into the Glengariff grits, which are Silurian. There is no great difference, physical or palæontological, between the Carboniferous at the top and the Silurian at the bottom." Mr. Hull went to the same place, and came to a totally opposite conclusion. He said—and this, it appeared to him, was a question for a jury of experts—"So far from there being perfect sequence, there is a break, and that break is something more than the break which occurs at Dingle Bay,* for it is a break betwixt

* Dingle Bay.	Kenmare R.	
	Kinahan.	Hull.
Lower Carboniferous	Lower Carboniferous	Lower Carboniferous.
Yellow Sandstones, 2000 feet	Yellow Sandstones }	Absent.
Old Red Sandstone, 4000 feet	Old Red Sandstones }	
Break	(No break)	Break.
Dingle Beds .....10,000 feet	Glengariff Grits	Glengariff Grits.

the Carboniferous on one side, and the bottom Silurian; the old red is entirely absent." It seemed to him (Mr. De Rance) to be a question of fact between these two geologists, and it was impossible for outsiders to determine without going to the ground. It will be curious to know which of the two views is right, because it appears an extraordinary thing that two trained observers, like Mr. Kinahan and Prof. Hull, should go to the same place and arrive at such opposite conclusions.

The Chairman said it could be easily accounted for. One gentleman looked through one pair of spectacles, and the other gentleman through another. The passage of the Lias, for instance into the Upper Trias had always

been a matter of difficulty; half a score of people had seen it one way and the same number another. So also with regard to the Carboniferous and the Permian, and he did not see why the same difficulty should not exist as to the Devonian and Carboniferous. He believed there were places where the Carboniferous passed insensibly into the Devonian. With regard to the latter passing into the Silurian, he had seen nothing like a passage himself. All the sections he had observed in the Isle of Man and elsewhere, showed them to be as unconformable as possible. The Old Red, or Devonian—whichever it was—lay quite unconformably on the rocks underneath. He hoped, when a jury was summoned to settle the difference between the two litigants, the testimony of witnesses only would be received, and that neither party would be permitted to give evidence himself. It was a subject about which those here could know little, unless they were on the spot to see for themselves.

NOTES IN PRESS BY THE AUTHOR.

The "Carboniferous Old Red Sandstones" are the arenaceous and argillaceous rocks, which occur at the base of, or in, the carboniferous rocks—See "Manual of the Geology of Ireland," chap. v.

In reference to the remarks of the Chairman: there are certain groups of rocks, passage beds from one formation to another, as to the age of which palæontological and statigraphical geologists are at variance. Those to which I would specially refer are:—

1st. *Arenig group*, the passage beds between the Cambrians and Cambro-Silurian; which some geologists would place in the Cambrians while others would put them in the Cambro-Silurian. These stratigraphically seem to belong to the Cambrians which palæontalogically they are allied to the Cambro-Silurians.

2nd. *The Devonian, or Lower Old Red Sandstone.* These are the passage beds between the Silurians and the Carboniferous,—stratigraphically they seem to belong to the Silurian, while some of the fossils are eminently of carboniferous types.

3rd. *Permian.* These are the passage beds between the Carboniferous and the Triasso-jurassic.—stratigraphically they are in part allied to the Carboniferous, and in part to the Triassic—while the fossils according to Baily, are almost entirely of Carboniferous types—I here call the rocks into which they graduate upwards, Triasso-jurassic, because there does not seem to be a true geological break between these two so-called formations, as already put forward by Le Conte and other geologists.

ALL the geologists who have examined the "Cork Rocks" carefully, including Griffith, Jukes, and their staffs, have come to the conclusion *that they are continuous from the Glengariff Grits up to the Carboniferous slates.*

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XV. SESSION 1878-9.

An ORDINARY MEETING of the Members of the Society was held on Tuesday, the 27th May, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

J. E. FORBES, Esq., F.G.S., President,
in the Chair.

ON THE OCCURRENCE OF A BED OF IRON PYRITES IN THE MILLSTONE GRIT IN THE WALSDEN VALLEY, NEAR TO THE REMAINS OF AN ANCIENT BLOOMARY.

By Mr. JOHN AITKEN.

The object of the present brief notice is to draw the attention of the Society to the existence of a bed of iron pyrites, or highly pyritised rock, in the millstone grit of the Todmorden Valley, and also the occurrence of the remains of a Bloomary, or ancient iron smelting furnace, the latter of which is situated close to the outcrop of the bed of pyrites, and which was in all probability the source from whence a supply of ore was obtained for use in this, and, perhaps, in other Bloomaries which existed in the immediate locality.

My attention was first directed to a large heap of slag at this spot by Mr. Robert Law, of Walsden, (a painstaking young geologist of that neighbourhood), some two or three years ago, during a geological ramble along that romantic gorge, which upon examination turned out to be the remains of an old Bloomary.

An interesting paper having been read about this time to the Bacup Literary Society, by Mr. James Kerr, of Crawshawbooth, on the occurrence of Bloomaries in the Rossendale Valley and at other places, excited some local interest in this subject and led to further and more careful observation, which has resulted in the discovery of several additional furnaces of this character on the border hills dividing the counties of Lancashire and Yorkshire, and also in other places in the two counties.

In connection with the situations of these Bloomaries, considerable difficulties have been experienced as to the source or sources from whence a supply of ore could have been obtained for the purpose of smelting, and various suggestions have been made to meet the case, — some attributing it to the bands of clay ironstone, of Lower Carboniferous age, which crop out on the hillsides of the district, whilst others have suggested that the ore was derived from the rich deposits existing in Furness, the position of the Bloomaries being determined by the presence in the immediate neighbourhood of each, of an abundant supply of fuel in the shape of timber—vegetable charcoal being exclusively used for smelting iron at that period; less difficulty, it is contended, would arise in conveying the ore to the fuel than in carrying the fuel to the ore. Neither of these suggestions, however, appear to me to offer a satisfactory solution of the difficulty. The bands of clay ironstone are too thin and inconsiderable to give an adequate and continued supply; and the distance at which Furness is situated

from the places of consumption involves difficulties of transit which, with the means of communication then available, appears to render this, as the supplying source, highly improbable. The question is, therefore, still involved in considerable doubt and uncertainty. That Bloomaries formerly abounded in various parts of Lancashire and Yorkshire, as well as in other parts of our country, and that they were always placed in situations so as to secure the advantages of an adequate supply of fuel, and also a sufficient current of air to give the necessary strength of blast for smelting the ore, is undoubted; but the question as to whence the material came for smelting has not as yet received a satisfactory answer.

The discovery of a body of iron pyrites, in close contiguity to the site of the Bloomary under consideration, places it in a different category to any which has been previously described in this part of the country, and furnishes a reason for my venturing to bring the fact before the notice of this Society.

As previously stated, the remains of the Bloomary are situated upon a knoll standing out on the S.E. side of the Walsden Valley, close to a small tributary stream, known as the Bottomly Brook, which, rushing down the steep declivity, has cut a deep channel in its face, thus giving a degree of prominence to the spot it would not otherwise possess; and at an elevation of some 250 feet from the level of the valley beneath.

The place, although not exhibiting on the surface any trace of the original structure, is easily distinguished by the scoria which has been accumulated at the spot, and which is also plentifully scattered around. This heap of dross must at one time have been considerably larger than at the present, it having been freely made use of for repairing the road which runs along the side of the hill and passes close by the site of the Bloomary.

The bed of iron pyrites to which reference has been made is situated near the top of the third member of the millstone grit, and is exposed in the bed of the stream, only a few yards to the N.E. of the elevation upon which the Bloomary stood, over which the water falls in a small cascade. The rock, a fine-grained, grey, rather soft sandstone, has the metal pretty equally distributed throughout its body; in some cases, however, it occurs in strings, and in others is found lining small cavities, which are distributed throughout the rock. The bed, so far as visible, appears to be about 16 or 18 inches in thickness; the means of observation are, however, somewhat limited, as the rock almost immediately plunges into the banks bounding the stream, and is lost from view. Mr. Robert Law, who has rendered me valuable aid, in not only pointing out the position of the Bloomary, but also in continuing the investigations, with the view of ascertaining whether this metalliferous rock occurs in other places in the neighbourhood or not, informs me that after a careful search he has not been able to detect its presence at any other spot. This confirms my previous observations, and renders it probable that it has only a local existence, and may, therefore, partake more of the character of a pocket or patch, having a local development, than that of a continuous and persistent bed. However this may be, the fact of the Bloomary having been located here, in such close contiguity to this bed of metalliferous rock, which would supply a desideratum not to be met with, so far as yet ascertained, at any other place in the neighbourhood, would naturally lead to the conclusion that it indicated something more than a mere coincidence, and that the position of the Bloomary was in all probability determined by the presence of the bed of iron pyrites at this spot.

I may further mention that the remains of at least two other Bloomaries are known to exist in this immediate locality—one about half-a-mile to the north, on the same

side of the valley, and one on the opposite side, about the same distance from the metalliferous sandstone—at both of which places considerable quantities of slag still exists. Whether these, and others which may yet be discovered, drew their supply of ore from this spot, or other outcrops of the pyritised rock were known to the ancient iron smelters but which is lost to the present generation, no evidence exists to show. It is, however, a not unreasonable inference to draw, that should this prove to be the only exhibition of this material, that it in all probability furnished the ore, at least in part, to all the furnaces in the immediate neighbourhood.

In order the more fully to understand the stratigraphical position of this bed of rock, I append a section of the third division of the millstone grit, as exhibited in the Walsden Valley, for the principal part of which I am also indebted to the gentleman whose name I have more than once mentioned during the reading of these remarks.

On the table are placed specimens of the pyritised rock and several pieces of the slag or scoria.

SECTION OF THIRD MILLSTONE GRIT, WALSDEN, NEAR TODMORDEN:—

	ft.	in.
Dark shale, the upper part very fossiliferous, containing goniatites avicula-pecten, &c.	60	0
Bed of pyritiferous rock	1	4
Grey micacious sandstone	30	0
Impure coal from 3 to		6
Underclay	6	0
Coal	0	6
Underclay	0	10
Light-grey thick-bedded sandstone	10	0
Grey micacious, flaggy sandstone, with numerous worm tracks near the bottom	30	0
Light fawn-coloured sandstone	4	0
Grey flaggy sandstone	15	0
Dark shale	10	0

Mr. PLANT asked if the occurence of iron pyrites was given in the memoir of the Geological Survey upon the Burnley coalfield, which comprised Todmorden and Walsden?

Mr. AITKEN: As far as I am aware no mention whatever is made of it, either by the Geological Survey or by local observers.

Mr. PLANT said that Mr. Aitken was very particular in going over that part of Lancashire, to note down all the heaps of slag; and it was surprising—there being such strong evidence to the existence of some sort of smelting, in the spot indicated by Mr. Aitken, that that had escaped his keen and searching examinations. The wonder was how anyone could have got iron from pyritic sandstone of such a character. The existence of quantities of sulphur, in iron in that state, and the well-known difficulties in getting rid of the sulphur to make it into a decent iron, made it astonishing that there should have been a possible production of anything like malleable iron from such materials. He supposed it would hardly pass in the markets of the present day as a saleable ore.

Mr. AITKEN: Not as a saleable ore, certainly.

Mr. PLANT continued: Therefore the per centage of iron got from the deposit must have been extremely small, and its production surrounded by all the objectionable features that belong to pyritic iron ore. He remembered having gone over the districts a few years ago, and very likely kicked his foot into the heaps of slag, but it never occurred to him that they were the *debris* of ancient smelting works, they looked like ordinary waste heaps which they were accustomed to see on the moorlands.

Mr. DICKINSON said that a considerable quantity of iron pyrites lay underneath the gannister coal in the neighbourhood of Wholaw Nook, between Bacup and Burnley. It occurred just at that part of the coal field where the upper

foot coal—which was a very sulphurous coal—united with the gannister, forming a thick bed. Underneath the floor of these united beds was a bed of iron pyrites, averaging almost a foot in thickness; it was pretty much the same as Mr. Aitken's sample; but neither from that irregular deposit underneath the gannister and upper foot coal, nor from the bed of pyrites, of which Mr. Aitken had produced a specimen, was iron—according to his experience—likely ever to have been manufactured. He thought if a bloomary had been used for any purpose in connection with that iron pyrites, it must have been for the sake of the sulphur and not of the iron. He did not know of any place where iron pyrites of that description was used for producing manufactured iron. In the neighbourhood of the Rio Tinto Sulphur Rocks, in Spain, it appears there are several old slag heaps.

Mr. PETER SPENCE said it would be very difficult to eliminate the sulphur from the pyrites, in any shape, so as to make a malleable iron out of it. Did Mr. Aitken know what proportion of pyrites there was in that bed of sandstone?

Mr. AITKEN: I do not.

Mr. SPENCE said he should not suppose it would be half the weight. A peculiar kind of pyrites was discovered a few years ago at Dove Holes, near Buxton, running under the limestone. It was in a different form altogether from that shown by Mr. Aitken, being disintegrated for the most part, and where hard easily crushed by the hand. The pyrites was in separate crystals, varying in size from a pin's head to a nut, and Mr. Macdougall was induced to try to work it economically, by roughly grinding and washing it. The attempt was not a success, however, commercially. There was the fact, nevertheless, of a large deposit of pyrites, running under the limestone rock at Dove Holes, and more distinctly separate than Mr. Aitken's sample seemed to be.

That Dove Holes pyrites, he might add, he analysed carefully in his laboratory, and found that it contained one grain of gold to the ton. From 6 or 7 lbs. weight he actually got a particle, visible as a black speck to the naked eye, but under magnifying power as a particle of gold. There was four pence worth of gold to the ton!

Mr. AITKEN said he quite recognised, and had experienced the difficulties suggested by Mr. Plant, and reiterated by Mr. Dickinson and Mr. Spence. The difficulty had occurred to him precisely as it had presented itself to them, that the ore was scarcely rich enough in metal, and that the extraction of the iron, with such appliances as people centuries ago had at their command, could have been no easy matter. But the question arose in his mind whether, as those bloomaries undoubtedly existed in considerable numbers, amongst the hills and valleys of that part of the country, and as smelted iron was also a certainty,—from whence did they get their supply of ore? Iron ore existed in the coal measures in thin bands, and he had found them frequently on all the hill sides in that particular district, but he had never yet been able to ascertain that the quantity was sufficient to be made at all available for commercial purposes. The nearest point, as far as he was aware, where an available supply of good material could be obtained, was Furness; and it struck him that to bring hæmatite from Furness to smelt on the borders of Lancashire and Cheshire would present difficulties of too serious a nature to be got over. When he hit upon that particular bed of rock in close proximity to the old bloomaries, the connection between the two naturally suggested itself to him: consequently he ventured to bring the matter before the society,—rather in a tentative form, he admitted, that day, because he should be sorry to assert positively that that rock had actually been made use of for the purpose described, though it was likely to have been, to some extent,

mixed perhaps with richer ores procured from other places. The hills were, in ancient times, covered with timber and brushwood; hence fuel would be inexpensive. Labour, too, would be cheap, and therefore, under the peculiar circumstances in which they were placed, the ore might have been made available for the purpose of smelting. Now, with regard to metal being obtained in small quantities and used for economical purposes, he might mention Alderley, where copper was found, distributed through the new red sandstone, in such minute quantities as barely to render its extraction remunerative at the present day. He had just been informed that the Alderley copper mines were now closed, and that made his argument still stronger. It was, he believed, an undoubted fact (he did not know whether Mr. Plant would deny it or not) that those rocks at Alderley were worked in pre-historic times; stone implements had been found in great abundance; and the rock had been disturbed and removed, and the holes filled up again. That no one would doubt; and he could not conceive any other purpose for which the rock had been so worked but the extraction of the metal. It seems a mystery how that could possibly have been done so long ago with anything like economy; but it might be that our forefathers possessed more metallurgical knowledge than we gave them credit for. Otherwise he presumed those rocks would hardly have been worked for such a purpose.

Mr. Spence referring to Mr. Aitken's specimen from Walsden, said that it was possible by a very slow method of calcination, to drive off the sulphur, so as to make a coarse species of cast iron; although at the present day no one would think of making iron from pyrites—at least under ordinary circumstances. As to the copper found at Alderley, that was a deposit of copper and various other metals, but in a form in which they were soluble. It was evidently the

debris of some former veins, where the metals had been mixed up and deposited along with the sandstone. The copper was in small grains interspersed through the body of the sandstone in a state of carbonate. The rock was ground down, and the metal extracted with hydrochloric acid. The mines were wrought until a year or two ago, until the low price of copper rendered it unprofitable.

MICACEOUS SANDSTONE IN THE BOULDER CLAY.

Mr. W. SPINKS, Stud.Inst.C.E., read a note "On the discovery of a block of Gray Micaceous Sandstone in the Boulder clay, at Warrington."

SHAP GRANITE IN THE BOULDER CLAY, IN LOWER BROUGHTON.

Mr. PLANT exhibited a specimen, which, he said, in some societies might excite a keen controversy, and very likely be disputed as to several of its features. It was held by some geologists who studied the Glacial Drifts, that they were able to trace to their origin a very large number of the boulders which were found in the boulder clay. Amongst those boulders, the presence of Shap granite in this district had been disputed, it being maintained that this peculiar granite was rarely found southward of Morecombe Bay from its central source in Westmorland. Mr. D. Mackintosh had spent years in tracking the lines of deposit of granite boulders, and had issued a map from which it would appear that the glaciers by which Shap boulders were transported mainly followed a North and North-Easterly direction. In the better drainage of Salford there had been made deep

cuttings through the boulder clay, and amongst the hundreds of boulders which he had preserved for the Peel Park Museum, he had one (which he now exhibted) that he had with his own hands taken from the clay, which effectually settled the question as to Shap granite having travelled into South Lancashire. The specimen was found in the true boulder clay, about 20 feet below the surface of the Irwell valley, close to Broughton Bridge. In order to be quite satisfied that he was not mistaken, he procured a piece of polished column from the Shap works, in Westmorland, and it so happened that the piece, so obtained, might have been a portion of the boulder which he exhibited to the meeting, so close was the resemblance.

Mr. DICKINSON said he thought Mr. Plant had carried the meeting with him. There was not, as far as he knew, any reason why the Shap boulders should not have been distributed over this part of Manchester. In the neighbourhood of Blackpool many specimens of hæmatite from the Ulverston district were to be found in the drift, and why might not a piece of Shap granite ?

Mr. PLANT said that hæmatites were found in the Salford cutting, as well—massive pieces weighing 12 or 14 lbs., but they were not from the Ulverston district. They came, he believed, out of the coal measures. They were very fair specimens of hæmatite ore, but did not exhibit the beautiful characters of the Ulverston hæmatites.

Mr. AITKEN said the question raised by Mr. Plant had occupied the attention of geologists, including Professor Phillips, for half a century, and no definite conclusion had yet been arrived at. He (Mr. Aitken) had never yet succeeded in finding a piece of undoubted Shap granite further south than a mile or two south of Preston: that piece was discovered in company with Professor Dawkins, and Mr. James Eccles, formerly of Blackburn, now of London. It

débris of some former veins, where the metals had been mixed up and deposited along with the sandstone. The copper was in small grains interspersed through the body of the sandstone in a state of carbonate. The rock was ground down, and the metal extracted with hydrochloric acid. The mines were wrought until a year or two ago, until the low price of copper rendered it unprofitable.

MICACEOUS SANDSTONE IN THE BOULDER CLAY.

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was picked up from a heap which had been obtained from the valley of the Ribble. Having inspected Mr. Plant's specimen he was fully convinced that it was undoubted Shap granite. The characters were so clearly marked that no one who had visited the Shap quarries, as he had on several occasions done, and seen the granite in various conditions, could have the slightest doubt about it. He should not discuss the reasons why that particular granite was so seldom found south of Preston, but such had been the fact hitherto; consequently Mr. Plant's discovery was of some importance. On the easterly side of the country the case was different: Shap boulders were of frequent occurrence, and he had himself seen, 10 or 12 miles south of York, some of large size. They had, he believed, been observed further south still.

Mr. MARTIN asked if Mr. Plant expected that the finding of that piece of Shap granite would decide the points which had been so long and so warmly discussed.

Mr. PLANT said it was not one point merely: there were several others that were contested, and the non-occurrence of Shap granites in this locality had been one of the strong points in arguing all those questions. Therefore the simple occurrence of this undoubted piece of Shap granite ought to have some measure of importance when the questions were re-argued. Shap granite, which had not been found before near Manchester, was found now; therefore that point must be given up; but he could not say that it would settle anything.*

* See "Results of a Systematic Survey, &c., of Erratic Blocks or Boulders of the West of England and East of Wales," by D. Mackintosh, F.G.S.—*Quart. Jour. Geo. Soc.*, No. 139, August 1879.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IX. VOL XV. SESSION 1878-9.

An ORDINARY MEETING of the Members of the Society was held on Tuesday, the 24th June, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKEN, Esq., Vice-President,
in the Chair.

ROOTS FOUND AT GREAT DEPTHS.

Mr. GRIMSHAW exhibited some roots, of the nature of which he said he had no information, which had been discovered in a lead mine near Holywell, in the joints of the limestone rock, at a depth of about 85 yards from the surface. The limestone in which they were found was dark in colour, but five or six yards above it there was a light colored band containing a great many shells. In driving the place towards the vein, or lode, in ground which had not been previously explored, a crevice was met with that extended along the level about 12 feet, and was, in its widest part, about 18 inches deep perpendicularly. It seemed to extend about 8 feet beyond the level on one side. The roots were found in the close joints of the limestone. He did not know whether they came from the top or not, but the surface was covered entirely with heather and grass—there were no

trees. If any gentleman could throw light upon this singular occurrence he should be glad. Mr. Grimshaw also exhibited some clay, evidently deposited by water, which was found in the crevice, and in which some of the roots were partially embedded in short lengths beyond the joints. The specimens exhibited afforded an idea of the character of the rock.

The CHAIRMAN asked if the crevice opened to the surface, or if there was any communication ?

Mr. GRIMSHAW: No; the crevice is horizontal. No swallow, or aperture tending in the direction of the surface could be found.

The CHAIRMAN said that a thin section of this root should be submitted to microscopical examination. Such an instance of vegetable life penetrating to great depths was remarkable, and he could not account for it.

Mr. GRIMSHAW said that the miners—many of them old men—assured him that they had never seen anything of the sort before.

Mr. PLANT, by request, sent the following Memorandum on the specimens:—Through my arriving late I was not aware that Mr. Grimshaw had shown the curious vegetable productions to the members, until the meeting was over, when I examined them. Their occurrence at any depth in a shaft or in a deep quarry is perfectly natural and proper, for these "Hyphomycetes" cannot exist with light and air, so are found flourishing under foundations of old ruins, down deep pits and in caverns, and even between the partings of strata of rocks far below the surface. I have seen and collected them from such situations many times. They have the appearance of dry, flattened, stringy twigs, matted and entangled in an irregular way—in fact, most people take them to be lost fibrous roots, some how dissevered from shrubs growing on the surface above; but it is

not so. These twigs are true independent species of fungi, whose nature is not thoroughly understood. I am not aware that they have been recently worked upon by any competent botanist. In the last edition of "Loudon's Encyclopedia of British Plants," 1866, they are described as belonging to a small group of such like anomalous plants under eight genera of "Byssacei," all the species of which are composed of brown opake fibres, mostly growing recumbent and forcing their way between crevices in rocks and stones in dark places, often very deep from the surface. The species brought by Mr. Grimshaw was a "Rhizomorpha" or an Ozonium—both much alike. The thallus of these is composed of decumbent, branched, entangled filiments, coriaceous or ligneous. All these Hyphomycetes are propagated by spores.

ON THE USE OF POWDER IN MINES.

By Mr. Richard John Barnes, M.E.

In May last year there was a discussion in this room on "The Lighting of Shots." I was sorry I could not attend, as it is a very important subject. The use of powder in mines under the Coal Mines Act of 1872 is, I consider, also an important subject, and the main object of this paper is to have the matter well considered and defined. I am not sure that there are any collieries working which, under the Act, can use powder in the daytime, *i.e.*, in ordinary working hours. All, or nearly all, mines give off firedamp, and though some require very much less air than others, yet when "straight work" is in progress extensively there is sure to be a good deal of "blue cap" visible. My rule for years past in driving "straight" work, where powder has been used, has been to allow an amount of air of 1000 (average)

cubic feet per minute per place, and not allow the air to go into more than 10 places in one split.* I have known many cases where 3000 and 4000 per place have been requisite, and I have seen over 5000 cubic feet per minute forced within a few feet of the face, and still a "blue cap" would show in the cutting.

It is not unusual for a split of air trailing its long round through 20, 30 or more places, slightly freshened up here and there on its way, foul before reaching several of the last, yet no "blue cap" shows either in cuttings or returns, most likely because it is so mixed with a "brown cap." Which then is the purest air for either place, or workmen? By "the Act," a thoroughly well-ventilated mine, with sufficient splits to give every 10 places air to themselves, cannot use powder in the day, whilst an ill-ventilated place with a split to every 30 places may do as its owners like, and poison everyone working there.

And now comes the time for asking what is meant by "a panel," and in a large pit how far does the finding of a little gas in a working place prevent the owners from using powder, except when ordinary workmen are out of it. The importance of this is very great, and in my opinion worth discussion.

Take a large pit, extending 2000 yards each way from the shaft. Say gas is found in extreme levels of one side, and out of those levels there is a district to the rise, which, to a certain point, has its intake and return common with the level district. Have the whole side and rise workings to be prevented from using powder? I say not. I say a panel is a separate split of air going from, and leading to, main returns, and therefore the restriction only applies to the workings in the one split of air wherein gas may have

* Thus, for 10 straight places I would have a split of 10,000 cubic feet per minute, and loose brattice.

been seen. Where "pipe" ventilation is used, and each working place has its own split, gas found in one such place would only lay that one place off from the use of powder (always providing there was no quantity of gas to make the pit dangerous.)

I believe many mining engineers take my view of the reading of the Act, but I somehow think powder has been prohibited in places rather against such view, and I would much like to hear some decided opinion about this.

At the collieries (Birley), of which I am in charge, in one of our pits raising about 900 tons per day, this is very important, inasmuch as we occasionally find a little gas in the goafs, and were we to have to use powder at night only, the mine could not be worked, and it is to the best of my thinking very safe. The system I have named, of airing fiery mines and using powder too, I have never yet known to fail, nor, in many thousands of straight places driven, have I known the slightest accident to happen. What the result has been of places aired by the same air going through 14, 20, or more, we most of us know. I have known cases of blown out shots, but beyond levelling the brattice of the place, I never saw anything done to hurt adjacent places. To stop this I some years ago, before the Act of '72 came in force, made a rule; I would never allow any shot to be fired without the fireman had previously seen and examined the drill-hole, and satisfied himself that such hole neither was in the roof, nor in the fast, at the side, nor drilled beyond the holing. This rule I have had carefully carried out, I may say, since 1870, and it has often been a matter of surprise to me that it was not made a "Government Rule." I believe it to be most important, and if the air be at all loaded (in one of the long round splits I have mentioned), and the mine at all dusty, a blown out or fast shot may do incalculable harm. From my

experience of colliers in Lancashire, I doubt there are many collieries where this simple rule is neglected. I speak confidently, because so many colliers said "it was never done where they came from," and many is the shot that has not been fired because the collier had put his cartridge in and "stemmed" against orders before the firemen came. I do not say there are not collieries where this is done, but simply there are a good many where it is not done.

One great reason against long splits is, where much dust exists on the road and in working places, such a great danger arises from a blown out shot, or a very slight explosion of gas being by such cause augmented into a heavy explosion. Many here know how the bodies of poor fellows found after an explosion are covered with *dust*, which often fills eyes, ears, and mouth. Therefore, the more dusty the mine, the more I would split my air, (remembering not to get such splits as would be too feeble for their work.)

These remarks may hardly bear upon the points I wish you to consider, but I make them before advancing an opinion I have, and which may be new to some of you, viz., I consider an Inspector of Mines ought to be left to judge whether a mine be safe for powder, which judgment would be guided by his knowledge of the splits, etc., and of the mine, and not by the words of the Act with regard to the "blue cap."

I believe, with plenty of air, judiciously used (of course this means good power, good airways, and careful overmen), powder can be used safely in any mine *not subject to outbursts;* that to prohibit it in all mines because it *may* have been abused in some would be unjust, and raise grave questions as to abandoning very many seams.

If the questions I have raised are considered worth discussion I shall be glad to hear your opinions upon them.

It is a matter of regret to me that I cannot attend to read this myself, but circumstances quite prevent me.

Mr. HIGSON said that, so far as he was able to appreciate it, the paper seemed to deal more particularly with the question as to whether it was the duty of an inspector to determine if a mine were safe for the use of gunpowder or otherwise. It seemed to him that it would throw a considerable onus upon the shoulders of any inspector who had to so determine whether a mine was safe or not, and probably the inspector might not like to have that onus resting upon him. As regarded what might or might not be "a panel," he did not think anyone was very clear about the law; and, probably, until the question was legally settled by some trial which would form a precedent for all future cases, it would remain undetermined. He believed, in the case of a mine which was worked, one district with powder and another without, that it was absolutely requisite to give official notice of such action, and no doubt the legislature had allowed considerable latitude to inspectors in determining what was really a panel. He believed that practically what Mr. Barnes suggested as being the best course had been, up to this point, in the hands of the inspectors, if any such case had presented itself to them.

Mr. GRIMSHAW said that he, like many others, had been greatly puzzled to decide what a panel really was. In the old time—say in John Buddle's time—they might take the ideal panel as being a level course, a jig driven out of it, the air split at the top, and returning and passing over a crossing the counter level for one sub-split, returned directly for the counter level for the other. But the question now, it seemed, was whether a separate split meant a panel or not; whether a panel needed to be distinctly separated from another panel, or whether the roads and works might be intermixed and simply ventilated by different splits. He did not know who was to decide this point; and with regard to Mr. Higson's observations, he

certainly thought, if he were in an inspector's place, he should decidedly object to have the onus of deciding the question which was raised by the paper, placed upon his shoulders.

Mr. HIGSON described, by a rough drawing on the blackboard, his definition of a panel, which, in so many words, required that the intake splits be made in the immediate vicinity of the shaft, and remain separated by natural strata until they reach the main return in the immediate vicinity of the upcast shaft. Where a simple over-casting separated the various air-currents in any mine, he should not think that those were distinct and separate panels, although they were, or might be, distinct and separate splits of air. Where, however, they got the living coal separating the return and the intake, the various splits of air-currents he should say might properly be called distinct and separate panels. He did not know whether that was the generally recognized acceptation of the term.

Mr. GRIMSHAW: Supposing you are working on the level from the downcast pit A, would not you call it a panel if that level was continued? These are dip workings exclusively.

Mr. HIGSON: The principle may be carried out to a very considerable extent by having over-casts and under-casts where the thickness is more than 10 yards, if you choose to indulge in that luxury.

Mr. GRIMSHAW: But suppose the air is split and goes down the brow B, and a certain portion goes along the level and ventilates the rise, would not you call that a separate panel equally with the dip panel?

Mr. HIGSON: No; if that stopping were destroyed there would be communication between the two air currents.

Mr. GRIMSHAW: Would you work in the rise and the dip and make them into separate panels in case anything happened?

Mr. HIGSON: It might be possible. But I remember an instance where there were separate panels, and where the violence of an explosion—in spite of 300 yards of solid coal—passed up this district, and across the pit, and went down into this panel (referring to the diagram), causing great mischief.

Mr. BURROWS said he quite agreed with what the previous speakers had said as to the impracticability of the Government inspectors deciding in any way. Many times one could not quite make up one's own mind, knowing all the circumstances of the case, and the inspector—unless he spent most of his time at the pit—would be in a still worse position. The question of "panels" had cropped up two or three times in his experience, and he thought in one case the judgment of the inspector and his (Mr. Burrows's) own opinion rather differed. In fact, he was not quite sure what was a panel and what was not. The deciding of what constituted the "blue cap" of General Rule 8 should, he thought, be left in a great measure to the common sense of those who knew all the circumstances of the case. They could not draw any hard and fast line.

Mr. GRIMSHAW said that he had been brought up to consider a panel a portion of work ventilated by a split from say a main horse road, such air being carried, after having passed through the places by means of a crossing over the main horse road, into a return air course running parallel, or approximately parallel, with the horse road.

Mr. HIGSON said the difficulty lay in the Mines' Regulation Act—not what they individually might think was a panel—and he thought the question had better be left with the inspectors of mines, as they were the source from whence mine owners and managers derived all their knowledge on such points.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART X. VOL. XV. SESSION 1879-80.

ANNUAL MEETING.

The ANNUAL MEETING of the Members of the Society was held on Tuesday, the 28th day of October, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN E. FORBES, Esq., F.G.S., President,
in the Chair.

Mr. Thomas Arrandale, Bradford Colliery, Manchester; Mr. James Carter, 1, Granville Terrace, Blackburn; Mr. Charles William Dixon, Mining Engineer, 19, King Street, Wigan; Mr. Richard Drinnan, Colliery Manager, Outwood Colliery, near Manchester; Mr. Isaiah Johnson, Colliery Manager, Unity Brook Colliery, Kearsley; Mr. Herbert Phillips, Digby Collieries, near Nottingham; Mr. Richard Unsworth, Colliery Manager, Mesne Lea Colliery, Worsley, were elected ordinary members of the Society.

The Report of the Council and the Treasurer's Balanee Sheet were read by Mr. J. S. Martin, Honorary Secretary.

REPORT OF THE COUNCIL FOR 1878-9.

Your Council feel much pleasure in being again enabled to report favourably as to the position of the Society, and to state that the number of members has been considerably increased during the past Session.

One honorary and 31 ordinary members have been elected, while the loss has been 15, viz.: 1 honorary, 1 life, and 6 ordinary members deceased, and 7 ordinary members resigned.

The total number now enrolled is 170, viz.: 17 honorary, 9 life, and 144 ordinary members.

Nine meetings have been held, and considerable interest has been shown in the Society's work.

Interesting and important papers have been read and discussed at the meetings, and the parts of the Transactions appertaining thereto have been distributed among the Members and Societies with which publications are exchanged. Several Societies which have for years received our Transactions without sending theirs in return have, on application being made to them, forwarded back numbers and promised regular exchange in future. The number of Societies exchanging has also been further increased.

Considerable additions have been made to the Library, and your Council has pleasure in reporting that space for an additional bookcase has been obtained, and the books are now so arranged as to be available for the use of members.

Arrangements have also been made with the Council of the Literary and Philosophical Society, for the daily use of their council-room by the members of this Society—subject to the convenience of their own members—for reading and consulting the books, maps, &c., contained in the Geological Society's Library.

Members wishing for books from the Library, and who are unable to call at the Society's rooms, can obtain them by communicating with the Hon. Secretaries. The expense of carriage to and fro, as well as the risk, being undertaken by the members applying.

Your Council regard with pleasure the kindly feeling exhibited by the Council of the Literary and Philosophical Society during the conduct of the negociations.

Your Council having made enquiry of the Owens College authorities, have received a reply to the effect that it is only the insufficiency of funds at their disposal which prevents the Museum being placed in a proper and suitable building, and that they hope, by an appeal to the public at no distant date, to be placed in a position to carry out their engagement.

The funds of the Society continue in a satisfactory state, and, as will be seen by reference to the balance sheet submitted herewith, the income has been sufficient to meet, not only the ordinary current expenses, but has enabled your Council to expend about £27 on new book-cases, and to reduce the balance owing to the Honorary Treasurer to the extent of £9 12s. 8d. The £600 belonging to the Society, which has for some years been invested in the 4 per cent. Guaranteed Stock of the Birkenhead Railway in the names of Henry Mere Ormerod and Andrew Knowles, it will be seen remains untouched. Both the outstanding liabilities of the Society, and the outstanding subscriptions, are small in amount.

There has been an increased demand during the Session for back volumes, as well as for separate numbers of the Transactions; and, for the information of those who may be desirous of completing their sets, your Council has pleasure in stating that the Secretaries, if applied to,

will supply either bound volumes or single parts at the published prices, if in stock.

An instructive and interesting excursion was made by a large number of the members of the Society to Garswood Colliery, near Wigan, where, by the kindness of Mr. William Smethurst, they were enabled to witness an extensive series of experiments with safety-lamps of different constructions in an explosive mixture of carburetted hydrogen (CH_4), which was obtained directly, by means of pipes, from the Wigan Nine feet mine.

The Society's thanks are due to Mr. Smethurst for the trouble taken to ensure the object of the excursion being attained, and for the hospitable manner in which the members taking part therein were entertained.

It was intended to visit a well-defined section of the coal measures during the same excursion, but the interest taken in the experiments prevented the visit. It is, however, to be hoped that at some future time it may be examined.

Attention is again called to the necessity of each individual member assisting in the work of the Society, by contributing papers and taking part in the discussions.

Your Council make known, with feelings of sorrow, the following loss during the Session by death from the roll of members:—Thomas Sopwith, M.A., F.R.S., F.G.S., Honorary Member, and for 35 years connected with the Society; Mr. H. W. Litler, Life Member; and Messrs. John Ashworth, W. H. Chadwick, George Hadfield, James Smallshaw, and Richard Smith; also Mr. Richard Radcliffe, whose decease it appears occurred in 1873.

Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

ABSTRACT OF RECEIPTS.

	£	s.	d.
1878-9.—To Bank Interest	0	6	4
,, Birkenhead Dividends.....	23	10	0
,, Sale of Transactions	9	17	7
,, Subscriptions and Arrears ..	153	10	0
,, Balance due to the Treasurer	18	4	5
	£205	8	4

The Investments consists of £600 Four per cent. Guaranteed Stock of the Birkenhead Railway in the names of Henry Mere Ormerod and Andrew Knowles.

ABSTRACT OF PAYMENTS.

	£	s.	d.
1878-9.—By Balance due to Treasurer	27	17	1
,, Library	6	11	11
,, Reporters	9	9	0
,, Treasurer's Reports, Printing, &c.	72	10	3
,, Postages.....	21	7	9
,, Collector's Commission	7	17	4
,, Rent	30	0	0
,, Attendance.....	2	10	0
,, Furniture	27	5	0
	£205	8	4
,, Balance brought down	18	4	5

HENRY M. ORMEROD, TREASURER.

14th October, 1879.

Audited and found correct,

CLEGG LIVESEY.

THE FOLLOWING PAPERS AND COMMUNICATIONS HAVE BEEN BROUGHT BEFORE THE ORDINARY MEETINGS DURING THE SESSION.

1878.

November. Nicolls, Thomas J., M.Inst.C.E., "Gypsum in the boulder clay."

Grimshaw, W. J., F.G.S., "Timbering in Mines."

" " "Sinking of surface owing to working of Coal Mines." Discussion.

December. Black, W. J., F.R.C.S.E., "Remarks on the Chessil Bank."

Pennington, Rooke, F.G.S., "On a Tooth of *Rhinoceros Tichorhinus*, found at the entrance to the Peak Cavern, Castleton, Derbyshire.

Law, Robert, "On Bones of Pleistocene Animals found in a broken-up cave in a Quarry, near Matlock, Derbyshire.

Dawkins, W. Boyd, F.R.S., "The Mammoth at Northwich."

1879.

January. Dickinson, Joseph, F.G.S., In Memory of Thomas Sopwith, M.A., F.R.S., F.G.S., *Honorary Member*.

Cook Charles, "Coal in Alluvial Soil at Moston."

Wild, George, "On Explosions in Mines." Discussion.

February. Garforth, W. E., "Blasting by means of Compressed Air in Mines."

De Rance, C.E., Assoc. M. Inst. C.E., F.G.S., "Notes on some Triassic Borings."

March. Smethurst, William, F.G.S., and James Ashworth, Mining Engineers, "Safety Lamps."

Atherton, James, "Notes on a Recent Boring in Openshaw, near Manchester, with remarks on the Manchester Coal-field, and the district to the East of it."

Bradbury John, "Section of above Boring."

April. Livesey, Clegg, "Section of Strata at Bradford Colliery."

Kinahan, G.H., M.R.I.A., "Diagram of the Irish Palœozoic Rocks, showing a nearly continuous sequence from the Coal Measures to the Cambrian."

May. Aitken, John, "On the occurrence of a bed of Iron Pyrites in the Millstone grit in the Walsden Valley, near to the remains of an ancient Bloomary."

Spinks, W., Stud.Inst.C.E., "Micaceous Sandstone in the Boulder clay."

Plant, John, F.G.S., "Shap granite in the boulder clay in Lower Broughton."

June. Grimshaw, W. J., F.G.S. "Roots found at great depths."

Barnes, Richard J., M.E., "On the use of Powder in Mines."

The Report and Balance Sheet were unanimously adopted, and ordered to be printed.

The following gentlemen were then proposed and seconded, and declared duly elected as Officers and Members of the Council for the ensuing year :—

President:

LORD LINDSAY, F.R.S., F.R.A.S.

Vice-Presidents:

RIGHT HON. THE EARL OF BRADFORD.
RIGHT HON. THE EARL OF DERBY.
RIGHT HON. THE EARL OF ELLESMERE.
SIR U. J. KAY-SHUTTLEWORTH, BART., M.P.

Ex-officio Vice-Presidents:

SIR PHILIP DE MALPAS GREY-EGERTON, BART., M.P., F.R.S.

JAMES HEYWOOD, F.R.S.	JOHN AITKEN.
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JOSEPH DICKINSON, F.G.S.	W. BOYD DAWKINS, F.R.S.
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RALPH FLETCHER, JUNR.	W. SMETHURST, F.G.S.
JOHN HIGSON, F.G.S.	PETER SPENCE, F.C.S.
CHARLES HARDWICK.	A. W. WATERS, F.G.S.
ROOKE PENNINGTON, F.G.S.	GEORGE WILD.
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EDWARD PILKINGTON. | CLEGG LIVESEY.

NEW ORDINARY MEMBERS.

Ashworth, James.
Ashworth, Thomas.
Atkinson, Samuel C.
Atkinson, W. N.
Baxter, Henry.
Bradford, Rt. Hon. Earl of.
Brocklehurst, Thomas.
Burrows, John S.
Clayton, Abel.
Ellesmere, Rt. Hon. Earl of.
Greener, W. J.
Greenwood, John, Jun.
Gregson, Edward.
Hedley, John L.
Holden, Charles H.
Hollingworth, George H.
Howell, John.
Jackson, Charles G.
Lindsay, Lord, F.R.S.
Longbotham, Jonathan.
Lupton, Arnold, F.G.S.
Maiden, Sampson.
Nall, Simon.
Nelson, William.
Perrin, J. Beswick, F.K., Q.C.P.
Settle, Miles.
Stephens, James H.
Statter, W. H.
Walshaw, John
Warburton, William.
Wells, Samuel B.

NEW HONORARY MEMBER.

G. H. Kinahan, M.R.I.A.

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Ashworth, John.
Chadwick, W. H.
Hadfield, George.
Radcliffe, Richard.
Smallshaw, James.
Smith, Richard.
} Ordinary Members.

Litler, H. W., Life Member.

Sopwith, Thomas, M.A., F.R.S., F.G.S., Honorary Member.

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Bangay, Richard.
Goodwin, George.
Greg, R. P., F.G.S.
Heelis, John.
Ogden, Samuel.
Walton, James F.
Wild, John.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3	Heywood, James, F.R.S., F.G.S.
1843-4-5	Egerton, Sir Philip de Malpas Grey-, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1849-50-1	Heywood, James, M.P., F.R.S.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1855-6-7	Egerton, Sir Philip de Malpas Grey-, Bart., F.G.S.
1857-8-9	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1861-2-3	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1865-6-7	Binney, E. W., F.R.S., F.G.S.
1867-8-9	Greenwell, G. C., F.G.S.
1869-70-1	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.Inst.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1876-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1877-8	Dickinson, Joseph, F.G.S.
1878-9	Forbes, John E., F.G.S.

LIST OF MEMBERS.

NOVEMBER, 1879.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1863	Aitken, John, Sandfield, Urmston. *Ex-President.*
1862	Alcock, Thomas, M.D., Oak Field, Ashton-on-Mersey.
1879	Arrandale, John Thomas, Bradford Colliery, Manchester.
1877	Arthur, David, Baxenden Collieries, near Accrington.
1865	Ashworth, Edward, Stagg Hills, Waterfoot, near Manchester.
1878	Ashworth, James, 56, Upper Duke Street, Southport.
1878	Ashworth, Thomas, 40, Lancaster Avenue, Manchester.
1877	Atherton, James, 16, Acresfield, Bolton.
1878	Atkinson, Samuel C., Stand Lane Colliery, Radcliffe.
1878	Atkinson, W. N., H. M. Inspector of Mines, Chilton Moor, Fence Houses, Durham.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1876	Barnes, R. J., Birley Collieries, near Sheffield.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool.
1879	Baxter, Henry, Tyldesley Colliery, Tyldesley.
1858	Bazley, Sir Thomas, Bart., M.P., Eyford Park, Stow-on-the-Wold, Gloucestershire.
1877	Beswick, James, Little Hulton, near Bolton.
1862	Beswicke, William, Balgay Terrace, Rochdale.
1838	Binney, E. W., F.R.S., F.G.S., 55, Peter Street, Manchester. *Ex-President.*
1867	Bolton, H. H., Newchurch, near Manchester.
1878	Bradford, The Right Hon. Earl of, Weston Park, near Shifnal.
1878	Brocklehurst, Thomas, Dean, Bolton.

Year of Election.	
1877	*Broeck, Ernest Vanden*, 124, Rue Terre Neuve, Brussells.
1877	*Brongniart, Charles*, Museum d'Histoire Naturelle, 57, Rue Cuvier, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1878	Burrows, John S., Atherton Collieries, near Manchester.
1859	Bryham, William, Ince Hall, Wigan.
1862	*Buccleuch, His Grace the Duke of, Whitehall Gardens, London, S.W.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1874	Byrom, W. A., F.G.S., 31, King Street, Wigan.
1879	Carter, James, 1, Granville Terrace, Blackburn.
1878	Clayton, Abel, 11, Chapel Walks, Manchester.
1878	Cooke, Charles, Moston Colliery, Failsworth.
1859	*Coulthart, John Ross, F.R.S.Lit., F.S.A. Scot., Crof[illegible] House, Ashton-under-Lyne.
1878	Cowburn, Henry, West Leigh, near Manchester.
1874	Crofton, Rev. A., M.A., The Parsonage, Reddish Green, Stockport.
1862	Cross, John, 78, Cross Street, Manchester.
1860	Crowther, Samuel, Bradford Estate Offices, Bolton.
1876	Cunliffe, P. G., The Elms, Handforth, near Manchester.
1860	Darbishire, R. D., B.A., F.G.S., 26, George Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *Ex-President.*
1877	*De Rance, C. E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1862	*Derby, The Right Hon. the Earl of, Knowsley.
1877	Derry, Jos, Sneyd Colliery, Burslem.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Ex-President.*
1859	Diggle, James, West Leigh Collieries, Leigh.

Year of Election.	
1879	Dixon, Charles William, 19, King Street, Wigan.
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, M.P., Worsley Hall, near Manchester.
1838	*Egerton, Sir Philip de Malpas Grey, Bart., M.P., F.R.S., Oulton Park, Tarporley. *Ex-President.*
1878	Ellesmere, The Right Hon. Earl of, Worsley.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1838	*Enniskellen, Earl of*, F.R.S., Florence Court, Fermanagh.
1878	Evans, T. F., H.M. Inspector of Mines, Amlwch, Anglesea.
1865	Evans, Walter, Longsight, Oldham.
1863	Farrer, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1857	Forbes, John Edward, F.G.S., 2, Shrubland View, Hoole, Chester. *Ex-President.*
1873	Garforth, W. E., Colliery Offices, Normanton.
1874	*Geikie, Archibald*, LL.D., F.R.S., Geological Survey Office, Edinburgh.
1858	Gerard, Lord, of Bryn, Garswood, near Newton-le-Willows.
1856	Gilroy, George, M.I.C.E., Hindley Hall, Wigan.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1863	Greenwell, G. C., F.G.S., 8, Prior Terrace, Tynemouth. *Ex-President.*
1874	Greenwell, G. C., junr., Poynton, near Stockport. *Hon. Secretary.*
1879	Greenwood, John, junr., Ashton Moss Colliery, Audenshaw, Manchester.
1879	Gregson, Edward, 11, Chapel Street, Preston.

Year of Election.	
1864	Grimshaw, W. J., F.G.S., Stand, Whitefield, near Manchester.
1877	Grundy, H. T., Radcliffe.
1877	Grundy, Joseph, Radcliffe.
1866	Hall, John, Balderstone, Walmersley.
1864	Hall, Robert, Hope Foundry, Bury.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester.
1874	*Hawkins, B. W.*, F.G.S., Century Club, East 15th Street, New York.
1875	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1877	*Hayden, F. V.*, State Geologist, Washington, U.S.A.
1878	Hedley, John L., H.M. Inspector of Mines, Fairfield, Liverpool.
1875	Hetherington, Joseph, 22, Booth Street, Manchester.
1874	Hewlett, W. H., Wigan Coal and Iron Co., Wigan.
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Ex-President.*
1862	Heywood, Oliver, Claremont, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1878	Holden, Charles H., Mawdesley Street, Bolton.
1877	Holding, William, Crossall Colliery, near Nottingham.
1878	Hollingworth, George H., Hollinwood, Manchester.
1878	Howell, John, Astley, near Manchester.
1874	*Hull, Professor Edward*, M.A., F.R.S., 5, Raglan Road, Dublin.
1878	Jackson, Charles G., Wigan.
1875	Jackson, J., 5, Wood Street, Bolton.
1877	Jackson, Lewis, Rocher Colliery, Ashton-under-Lyne.
1877	Jobling, John, Barcroft Hall, Cliviger, Burnley.
1879	Johnson, Isaiah, Unity Brook Colliery, Kearsley.

Year of Election.	
1874	Johnson, J. H., F.G.S., 64, Albert Road, Hesketh Park, Southport.
1844	*Joule, J. P., L.L.D., F.R.S., 12, Wardle Road, Sale.
1879	*Kinahan, G. H.*, M.R.I.A., Ovoca, Ireland.
1856	Knowles, Andrew, High Bank, Pendlebury. *Ex-President.*
1859	Knowles, John, Westwood, Pendlebury. *Ex-President.*
1877	Knowles, Lees, Westwood, Pendlebury.
1858	Knowles, Thomas, M.P., Darnhall Hall, Winsford, Cheshire. *Ex-President.*
1858	Lancaster, John, F.G.S., Bilton Grange, Rugby.
1879	Lindsay, Lord, F.R.S., 47, Upper Brook Street, London. *President.*
1862	Livesey, Clegg, Woodley, Stockport.
1877	Livesey, Thomas, Hitherlow, Romiley, near Stockport.
1878	Longbotham, Jonathan, Norley Colliery, Wigan.
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., Crossgates, near Leeds.
1861	Lynde, J. G., F.G.S., Town Hall, Manchester.
1878	Maiden, Sampson, Bridgewater Villas, Stockport.
1873	Martin, Joseph S., F.G.S., H. M. Inspector of Mines, Park Villas, Prestwich. *Hon. Secretary.*
1876	Moore, Alfred, C.E., 5, Clarence Street, Manchester.
1838	*Morton, Charles*, The Grange, Southport.
1874	*Morton, G. H.*, F.G.S., 122, London Road, Liverpool.
1878	Nall, Simon, Newbold, Rochdale.
1878	Nelson, William, Leigh, near Manchester.
1875	Nesbitt, George, China Buildings, St. Ann's Street, Manchester.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1874	*Ormerod, G. W.*, M.A., F.G.S., Woodway, Teignmouth.
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester.

Year of Election.	
1874	*Owen, Professor Richard*, D.C.L., F.R.S., &c., British Museum, London, W.C.
1862	Park, James, Fern Hill, Bury.
1876	Peace, George, Monton Grove, Eccles.
1877	Peace, Maskell W., F.G.S., Wigan.
1876	Penman, J. Hugh, 2, Clarence Buildings, Booth Street, Manchester.
1877	Pennington, Rooke, F.G.S., 20, Mawdsley Street, Bolton.
1878	Perrin, J. Beswick, F.K., Q.C.P., F.L.S., Leigh, near Manchester.
1879	Phillips, Herbert, Digby Collieries, near Nottingham.
1861	Pickup, Peter, F.G.S., Towneley Colliery, Burnley.
1877	Pickup, Peter Wright, Dunkenhalgh Collieries, Church, near Accrington.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester.
1873	Pilkington, Edward, Clifton Collieries, near Manchester.
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1867	Radcliffe, James, Lord's Field Colliery, Ashton-under-Lyne.
1874	*Ramsay, Professor A. C.*, LL.D., F.R.S., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton.
1877	Robins, George, Ashton, near Newton-le-Willows.
1873	Seddon, J. F., Great Harwood Collieries, Accrington.
1866	Selby, Atherton, Mining Engineer, Leigh.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., M.P., Gawthorpe Hall, Burnley.
1864	Smethurst, William, F.G.S., Garswood Hall Colliery, Ashton, near Wigan.
1873	*Smith, R. Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Ex-President.*
1838	Smith, G. F., M.A., F.G.S., Grovehurst, Tunbridge Wells.

Year of Election.	
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1862	Spence, Peter, F.C.S., Erlington House, Seymour Grove, Old Trafford.
1859	Statter, Thomas, Stand Hall, Bury.
1878	Statter, William H., Town Hall, Bury.
1878	Stephens, James Henry, Leigh, near Manchester.
1877	Tomlinson, Thomas, 3, Richmond Terrace, Whitehall, London, S.W.
1873	Tonge, James, Woodbine House, Westhoughton, near Bolton.
1876	Topping, Walter, Ashton, near Wigan.
1858	*Trafford, Sir Humphrey de, Bart., Trafford Park, Manchester.
1876	Unsworth, John, Scot Lane Collieries, near Wigan.
1879	Unsworth, Richard, Mesne Lea Colliery, Worsley.
1877	Waddington, Henry, Burnley Collieries, Burnley.
1877	Waddington, John, Burnley Collieries, Burnley.
1862	Wadham, Edward, Millwood, Dalton-in-Furness.
1862	*Walsh, Eli, Over Darwen.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1879	Warburton, William, Norbury Colliery, near Stockport.
1874	Waters, A. W., F.G.S., Woodbrook, Alderley Edge.
1878	Wells, Samuel B., 130, Bradford Street, Haulgh, Bolton.
1877	West, T. E., 65, Werneth Hall Road, Oldham.
1877	Wheeler, Harold George, Cockeymoor Colliery, Radcliffe.
1865	Whipp, Thomas, Hawthorn Villas, Prestwich.
1867	Wild George, Bardsley Colliery, Ashton-under-Lyne.
1877	Wild, Joseph, 25, Long Causeway, Farnworth, near Bolton.
1860	Wild, Samuel, Dean House, Buersill, Rochdale.
1876	Winstanley, Robert, Lancaster Avenue, Manchester.
1876	Woodward, H. A., Clifton, near Manchester.
1877	Yates, T. M., Park Hall Colliery, Horwich Junction, near Bolton.

PRESENTATIONS TO THE LIBRARY, 1878-79.

Barrow Naturalists' Field Club.—Transactions. Vol. 3. 1878-9.

Belfast Natural History and Philosophical Society.—Proceedings. 1877-8. From the Society.

Birley, Hugh, M.P.—Reports of the Inspectors of Mines. 1878.

Bristol Naturalists' Society.—Proceedings. Vol. 2. Part 3. 1878-9.

Chesterfield and Derbyshire Institute of Engineers.—Transactions. Vols. 1, 2, 3, 4, and 5. From the Council.

Cornwall and Devon.—Reports and Proceedings of the Miners' Association. 1878.

Cornwall.—Royal Institution Journal. Nos. 20 and 21. 1879.

Edinburgh Geological Society.—Transactions. Vol. 3. Part 2.

Geological and Polytechnic Society of the West Riding of Yorkshire.—Proceedings. Vol. 7. Part 1. 1878. From the Society.

Institution of Mechanical Engineers.—Proceedings. Nos. 1, 2, 3, and 4. 1879. From the Council.

Ireland.—Journal of the Royal Geological Society. Vol. 5. Parts 1 and 2.

Iron and Steel Institute—Journal. Part 2. 1878.

Leeds Philosophical and Literary Society.—Report for 1878-9. From the Council.

Leicester Literary and Philosophical Society.—Transactions. Part 5. 1850 to 1855, and Report for 1879. From the Council.

Liverpool Geological Society.—Proceedings. Part 4. Vol. 3, and Part 1. Vol. 4. 1878. From the Society.

London Geological Society.—Quarterly Journal. Nos. 137 to 139, and Abstracts of Proceedings for the Session 1878-9. From the Society.

London Geologists' Association.—Proceedings. Nos. 1, 2, and 3. Vol. 6. 1878-9. From the Council.

Midland Institute of Engineers.—Transactions. Parts 46 and 47. Vol. 6.

North of England Institute of Engineers.—Transactions. Parts 1-6. Vol. 18. From the Council.

North Staffordshire Institute of Engineers.—Transactions. Vols. 1 and 3, and Parts 1-3. Vol. 4. From the Council.

Oxford University.—Supplementary Catalogue of Books on Natural Science added to the Radcliffe Library, in 1878. Per Dr. H. M. Ackland, Librarian.

Royal Institution of Great Britain.—Proceedings. Vol. 8. Part 6. No. 69. From the Council.

Royal Society.—Proceedings. Vol. 16. From the Council,

Royal Physical Society.—Proceedings. 1876-8. From the Council.

South Staffordshire and East Worcestershire Institute of Mining Engineers.—Transactions.

South Wales Institute of Engineers.—Proceedings. Vol. 11. Part 6. 1877-8. From the Institute.

The Owens College Calendar. Session 1879-80. From the Council.

West of Scotland Mining Institute.—Transactions. Parts 1-6. 1879. From the Council.

Wigan Free Library.—Index Catalogue. 1878.

Whitaker, W.—Essay on the Post Tertiary Deposits of Cambridgeshire, by Jukes-Browne.

ANNUAL REPORTS, FROM THE COMMITTEES.

Chester Society of Natural History. 1878-9.

Devon and Exeter Free Library. 1878-9.

Dundee Free Library. 1878.

Leicester Town Museum. 1879.

Warwickshire Natural History Society. 1879.

Wigan Free Library, 1878, and Index Catalogue, 1878.

AMERICA.

Agassiz, Alexander.—Museum of Comparative Zoölogy, Cambridge, U.S.A.

Annual Report of the Curator, 1877-8.

Bulletin. Vol. 5. Nos. 2-14.

Vol. 5. Terrestial Air-breathing Mollusks, with plates. July, 1878.

Hayden, F. V.—Bibliography of North American Invertebrate Paleontology.

First Annual Report of the U.S. Entomological Commission. 1877. Relating to the Rocky Mountain Locust.

Bulletin of the U.S. Geological and Geographical Survey. Vol. 4. Nos. 3 and 4. Vol. 5. No. 1.

Catalogue of the Publications of the U.S. Geological and Geographical Survey.

Annual Report, 187 .

Sun Pictures of Rocky Mountain Scenery.

Selwyn, A. R. C., F.G.S.—Geological Survey of Canada.—Mesozoic Fossils. Vol. 1. Parts 1 and 2.

Smithsonian Institution, U.S.A.—Annual Report for 1877. From the Council.

Transactions of the American Institute of Mining Engineers. From the Council.

AUSTRALIA.

Report of the Free Public Library, Sydney, New South Wales.

Report on the Construction and Working of Railways in New South Wales. 1876.

Report of the Mining Department of New South Wales. 1877.

Mineral Statistics. Victoria. 1878.

Report of the Chief Inspector of Mines. Victoria. 1878.

Reports of the Mining Surveyors and Registrars. Victoria. October, 1878, to June, 1879.

CANADA.

Canadian Journal. Vol. 1. Part 1. New Series. 1879.

FOREIGN.

Deutsche Geologische Gesellschaft. Index of Vols. 21 to 30. Proceedings. Vol. 30, and Parts 1 and 2. Vol. 31. From the Society.

Geographischen Gesellschaft in Bern. Jahres Bericht. 1878-9.

Académie Impérial de St. Pétersbourg. Mémoires. VII^{e} Série. Tome 26. Nos. 5-9.

R. Accadamica dei Lincei.—Transuntis. Vol. 3. Fasc. 1-7. 1878-9.

Società Toscana di Scienze Naturali-Atti. Vol. 4. Fasc. 1. 1879. From the Society.

Société Vaudoise des Sciences Naturelles. Lausanne. Bulletin. Vol. 16. Nos. 81 and 82. 1879. From the Society.

Société D'Histoire Naturelle. Toulouse. Bulletin Treizieme Année. 1879. From the Society.

Société Géologique du Nord. Lille. Annales. Tome 5. 1878. From the Society.

Verein fûr Erdkunde zu Metz. Bericht. 1878.

Naturwissenschaftlichen Gesellschaft Isis in Dresden.—Sitzungsberichte. Parts 7-12, 1878; Parts 1-6, 1879. From the Society.

Naturforschenden Gesellschaft zu Leipzig. — Sitzungsberichte. Jahrgang 5. Parts 1-9. From the Society.

Van den Broeck. Sundry Pamphlets.

BOOKS PURCHASED, 1878-9.

Coal Mines Inspection: Its History and Results. R. Nelson Boyd. 8vo. 1879.

Geological Magazine, 1879.

Palœontographical Society. Monograph. Vol. .

Physical Geology and Geography of Great Britain. A. C. Ramsay. d. edition. 8vo. 187 .

Zeitschrift für, das Berg. Hutten und Salinen-Wesen. Vol 27. 1878. With Plates.

Societies with whom the Society Exchanges its Transactions and Institutions and Journals to whom a Copy is sent Free.

I.—England.

London	**British Museum.**
	Geological Society.
	Geological Survey.
	Geologists' Association.
	Institute of Mechanical Engineers, Victoria Street, S.W.
	Iron and Steel Institute.
	Royal Institution.
	Royal Society.
Manchester	**The Owens College.**
	Literary and Philosophical Society.
	Free Library.
	Scientific Students' Association.
	Salford Royal Museum and Library.
Barnsley	Midland Institute of Mining Engineeers.
Birmingham....	Free Library and Museum.
Bristol	Natufalists' Society.
Cambridge	Geological Museum, University.
	University Library.
Chesterfield	Institute of Mining Engineers, &c. (in bound vols.)
Cornwall	Royal Geological Society, Penzance.
	Royal Institution, Truro.
Dudley.....	South Staffordshire and East Worcestershire Institute of Mining Engineers.
Exeter	Albert Memorial Museum.
Leeds	Geological and Polytechnic Society.
	Philosophical and Literary Society.
Leicester	Literary and Philosophical Society.
Liverpool.....	Geological Society.
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Oxford.....	Bodleian Library.
	Radcliffe Library.

South Shields .. Public Free Library.
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Swansea ..... South Wales Institute of Mining and Mechanical Engineers.
Truro ..... Miners' Association of Cornwall and Devon.
Warwick ..... Natural History Society.
Watford ..... Natural History Society.
Wigan ..... Free Library.
Mining School.

II.—Scotland.

Dundee..... Free Library and Museum.
Edinburgh .... Geological Society.
Royal Society.
Royal Physical Society.
Advocates Library.
Glasgow ..... Geological Society.
Natural History Society.
Hamilton ..... West of Scotland Mining Institute.

III.—Ireland.

Dublin ..... Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.
Belfast..... Natural History Society.

IV.—Foreign Societies.

Berlin ..... Geological Society of Germany.
Calcutta ..... Geological Survey of India.
Christiania .... Royal University of Norway.
Halle, A.S..... Verein fur Erdkunde.
Lausanne (Suisse) Société Vaudoise des Sciences Naturelles.
Lille..... Société Géologique du Nord.
Pisa..... Sociata di Scienci Naturali.
Rio de Janiero.. Museu Nacional.
St. Petersburg.. Academy Imperial.
Turin ..... Academie Royale.

V.—Canada and United States.

Montreal ..... Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director).
M'Gill College, (Principal, J. W. Dawson, F.G.S.)
Toronto..... Canadian Institute.
Albany, U.S .. Verplanck Colvin.
Boston, U.S. .. Free Library.
Columbus, U.S. Ohio, Geographical Survey of (Dr. J. S. Newberry, F.G.S.
Easton. U.S. .. American Institute of Mining Engineers.
Indianapolis, U.S. E. T. Cox, State Geologist.
New Haven, U.S.. Professor O. C. Marsh, F.G.S.
Washington, U.S. Smithsonian Institution.

VI.—Australia.

Melbourne .... Public Library of Victoria.
Sydney..... Free Public Library.
Royal Society of N. S. Wales.
Newcastle..... John Mackenzie, F.G.S.

VII.—Scientific Journals, &c.

Geological Magazine, Geological Record, Mining Journal, Colliery Guardian.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XI. VOL XV. SESSION 1879-80.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 25th day of November, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

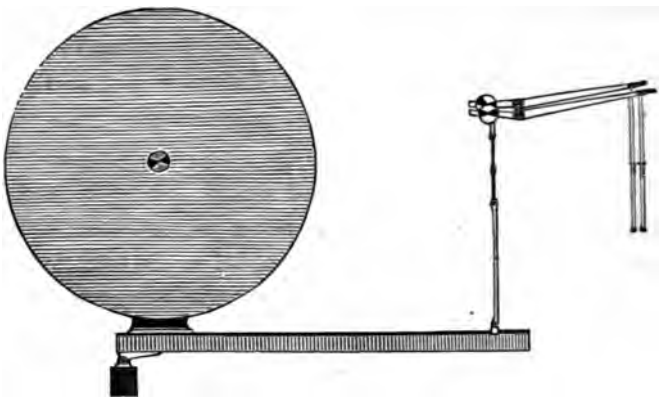
JOHN AITKEN, Esq., Vice-President,
in the Chair.

Mr. Thomas Burns, Plank Lane Colliery, Westleigh, Leigh, Lancashire; Mr. William Melling, Mining Engineer, Plank Lane Colliery, Westleigh, Leigh, Lancashire; Mr. John Sixsmith, Colliery Manager, Snydale Hall Colliery, Chequerbent, Bolton, were elected ordinary members of the Society.

BURN'S PATENT BRAKE.

Mr. PERRIN read a paper on the above subject, setting forth—That its main feature is the short block, which enables a very much increased leverage and consequently pressure per square inch, to be obtained over the ordinary strap brake; that its advantages are efficiency, cheapness, simplicity, and capability of having one or more applied to

the same brake-flange, thereby still further increasing



its power and rendering the reversing of the engine unnecessary whilst banking.

Mr. WOODWARD said that the brake which had been described, offered, it seemed to him, very little friction as compared with the double clip brake. There appeared to be greater leverage, and the mechanical arrangement appeared to be simple. Still he did not think they would get the same resistance with this brake that they got with one that went round the whole circumference.

Mr. NELSON said that the brake was able to stop the powerful winding engines (36 inch cylinders, 6 ft. stroke, 40 lbs. steam pressure, and 16 ft. drum) in full operation, with empty cages in two strokes and with the full pressure of steam on, at the Plank Lane Colliery with which he is connected, thereby proving it to be a powerful one.

Mr. E. PILKINGTON said that the objection to it, so far as he could see, was that the power being concentrated upon a very small area of the drum or brake-flange, it would be liable to strain any weak point or necessitate excessive strength.

Mr. GEORGE WILD said that he had always been taught

to believe that a double clip brake was the most effective for stopping an engine with, either suddenly or gradually. It seemed to him that the application of the brake which had been described must have a tendency to disturb the fixings more than a double clip brake would. The large wheel enclosed with a double brake strap would receive the pressure from all directions and would not press unduly on any one point. The friction being increased per square inch on the short block might be equal to the total friction on the larger brake, but he thought the tendency was to disturb the fixings. He did not see a great advantage in the new brake, though not practically acquainted with it. He thought a little wet or grease getting between the short block and the flange would more readily destroy its friction than would be the case with a double strap brake.

Mr. HOLLINGWORTH did not see that there was any likelihood of any wet or grease getting in, as suggested by the previous speaker, no doubt theoretically, at least, there would be the same friction as when the block was longer. He thought the principal objection was, that there might be some tendency to disturb the drum or fixings.

Mr. PERRIN said he had brought the subject forward simply because he had seen the brake at work and considered it admirably adapted for its purpose. The objections seemed to resolve themselves into a question of "ifs" and "buts"; "it might do this," or "it might do that." There could be no chance of the drum or flange becoming greasy, or getting smashed with the pressure. The brake had been tested for three years, both in sinking pits and in winding shafts, and he thought that ought to be a very good argument in favour of the efficacy of it. It is simply absurd to suppose that an homœopathic dose of pitch pine can disturb the bearings or fixings of a winding drum capable of bearing at least a thirty ton strain.

NOTES ON THE GEOLOGY OF THE SHAP DISTRICT.

By Rev. A. Crofton, M.A.

The object of the following paper is to endeavour to show that a part, at least, of the accumulations of sand and stones lying in the neighbourhood of Wasdale Crag, is due to the action of glaciers.

In a very interesting paper by Mr. D. Mackintosh in the *Geological Magazine*, (No. lxxiv. August, 1870,) the action of coast ice is brought forward to account for the wide dispersion of boulders of granite from Wasdale Crag, but the few notes here offered will not interfere with the conclusions drawn in that paper, for probably, the deposits under consideration are the result of causes which were in operation long after the great dispersion of Shap granite boulders over Stainmoor Pass.

Be this as it may. I offer the following notes and diagrams as likely to be of some interest, not because they deal with any new discovery, but as bringing forward what seem to me to be well marked instances of glacial action in the usual sense of the word, taking place here in England, just as it does now in the Alps, and supplementing, perhaps, the work of ice floes and ocean currents.

In no part of the Lake district are there more evident marks of glacial action than in the valley just above the Shap wells, and in the immediate neighbourhood—heaps of *debris*, smoothed surfaces of rock, scratches and furrows—all remind one instinctively of an Alpine valley. Amongst the hills at the head of the dale is an ancient lake, now drained and converted into a turbary. The north bank of this lake is formed by the granite flanks of Wasdale Crag,

on which lie extensive deposits of what for the present I am inclined to call "moraine," full of fragments, round, sub-angular, or cut off sharply into shapes of a semicircular character. The fragments are of all sizes, derived mainly from the neighbouring rocks—granite, slate, and sandstone; they are, many of them, smoothed on one side only, others appear to have been turned over, and after having been ground down on one side, to have presented another to the wearing action. Drawings of several of these accompany this paper, but the stones themselves have been thrown away. I had at one time a considerable number. One or two of them are cut down into figures resembling those of polished gems, and seem to declare plainly that they have been held, as in a vice, by the lower surface of a glacier, and ground down against an abrading rock surface, as gems are "facetted" by a jeweller.

That many of the stones should be rounded as if by the sea, or should prove to be strangers to the district, is not astonishing, for there evidently were considerable deposits of a drift character before the Shap glacier came into existence, and nothing is more natural than that the moving ice should plough out many of these accumulations and mingle their contents with recent and sharply angular fragments, sometimes taking hold of them and grinding down, on one side at least, their rounded outline to a plain surface. The heaps of gravel and sand with boulders and a coarse kind of clay, on both sides of the peat moss, I take to be the remains of moraines, the north and south laterals of a glacier which formed the bed of the lake, or enlarged it from pre-existing hollows. The northern of these moraines rests on the smoothed surface of the granite, the southern on the hard splintery altered slates of the Coniston series. Just below the eastern or lower end of the lake is a long narrow mound of moraine standing out in the valley,

parallel to the course of the Wasdale beck and tolerably conspicuous in the landscape, either in the uphill or downhill view.

Into this heap the stream has cut considerably, showing its contents to be similar to those which compose the northern moraine, with perhaps a smaller number of granite fragments in proportion to bulk, which may easily be accounted for by its being the united product of two lateral moraines only one of which contained granite fragments. The accompanying sketches and plans will perhaps make this clear. The tarn above appears to be of true glacial origin, having been scooped out by the ice in very ancient times and gradually filled with water as the glacier retired before a warmer climate.

The action of the stream on the terminal moraine, which had hitherto dammed up the water, gradually lowered the barrier (and consequently the water-level in the lake) until only a shallow swamp was left, where the muddy sediment of the former lake gave place to mossy bogs and peat deposits. It is now to some extent drained and across it run the posts and wires of the telegraph.

The glacier of Wasdale was one of a very large system of ice fields which can be traced over the greater part of North and East Lancashire and even over Stainmoor to Scarborough. It is easily recognised by the presence of boulders of a particular kind of granite, known as Shap granite, in which the felspar is disposed in large crystals of a rhomboidal form, often an inch or so across. A large fragment of Shap granite roughly resembles a piece of pudding studded with large raisins, and is not soon mistaken for any other variety, though I have seen specimens in Eskdale and the Ravenglass district which approached very near to it. In some places I found in it masses of a round shape, consisting of mica and quartz, of a bluish grey tint, containing very little

felspar. Here and there it is stained with iron, sometimes, again, it is green in colour or full of yellow ochreous clay.

The granite is derived altogether from the Wasdale Fell, on the north of the tarn, and may be traced in large boulders down the course of the valley, the sides of which are thickly studded with them.

There are some quarries for granite in the side of the hill, a little above the bridge of the once celebrated "North Road," which passes at the foot of the lake; here good sections may be seen and specimens obtained. A little further down, and on the left bank of the beck, are some well-exposed surfaces of smoothed and grooved rock, close to the side of the road. The course of all the striæ on these is roughly parallel to the present course of the stream, just as we should expect if a glacier once passed down the valley.

On the opposite side rise hills of hard black altered rocks and flaggy sandstones of the Coniston series. Just below the crest of the highest point is an old stone hut, from which an extensive view is obtained of the course of the glacier. Here the old road crosses the fells on its course towards Kendal, having left the "North Road," of which it was the predecessor, at a point a little below the bridge, and crossed the beck on a bridge of its own, of which the remains are still to be seen. At the point where these roads diverge, and on the right or south side of the Wasdale beck, we perceive clays and sands lying on the glaciated surface of the Coniston rocks, and distinctly stratified. On the left hand side, a little lower down, we reach the sandstones of the Coniston series, where they join, in an altered state and in a confused manner, the great mass of the granite. Lower down still, the Coniston rocks cease, and give place to the Old Red Sandstone, at a place where the beck has formed a small waterfall, tumbling over the hard altered Coniston rocks, here as hard as clinkstone, into a deep pool

scooped in the softer sandstone. The red rock is variegated with greenish sandstones in places, and is also found in the form of a coarse conglomerate, and in intermediate states between a coarse grit and a finely grained sandstone. At Shap Wells, close to the junction of the Red Sandstone and the Coniston slates, is a mineral spring containing salines to the extent of about 47 grains in a pint. Below the Wells, the sandy and shaley beds of the Carboniferous series are found. The most accessible quarries are near the high road, close to the toll-bar, about a mile from Shap. Here may be clearly seen the deposits of grey and brown pinel, mentioned in Mr. Mackintosh's paper, which contain many fragments of Shap fell granite. With these, however, I am not at present concerned, my object is to assert the claim of an ordinary glacier, acting in the ordinary way, to the honour of having affected the phenomena of Wasdale Beck, in the immediate neighbourhood of the Shap granite deposit. That a large system of ice floes carried away and widely dispersed, what a very limited glacier brought down is both possible and probable; as is the other supposition, to which I rather incline, that when the days of submergence were over, the Shap glacier resumed its ancient work for a season, and threw up the heaps of moraine, now visible, in comparatively recent times.

The CHAIRMAN (Mr. Aitken) said he had been much pleased in hearing the remarks made by the reverend gentleman, for they had reference to a district which he himself had visited more than once, and had been interested in investigating the phenomena brought before them by Phillips, Mackintosh, and many other observers. He noticed that in the paper the red rocks were described as old red. He believed, however, from the information he had, that the whole of those red rocks in that part of the country had been removed from

the old red formation with which they were formerly classed, and were now considered of lower carboniferous age. The Coniston rocks were very interesting, as showing the altered condition in which many of them were found. Some of them were brick-red in colour, were easily fractured, and showed evident signs of having been subject to very considerable heat. The district was one of great interest, and had led many geologists to examine it for years past.

Mr. PLANT remarked that there was no room for criticism in the paper. Mr. Crofton had described what he saw, but did not advance any special theory thereon. The specimens produced by Mr. Crofton were very interesting, and were undoubtedly moraine pebbles. He remembered a professor saying it was impossible to tell one from a glacial boulder, but he did not agree with him. He had not the slightest hesitation in accepting those before him as having been worked out in the manner described by Mr. Crofton. He had seen many such in Wales, and they always exhibited a rough character on the one side, and a beautiful attempt at polishing at another part of the stone.

Mr. BROCKBANK observed that Wasdale Crag was of special interest to Lancashire geologists, for a short time ago it was the generally received opinion that all the boulders we had here came over Shap fells; and in 1870 he read a paper before the Philosophical Society of Manchester, which Mr. Crofton was apparently not aware of, or he would have seen that he had been forestalled in a good deal that he had been speaking about. In the earlier part of that paper he traced out the origin, as far as he could, of the boulders in our Lancashire drift, and in the concluding paragraph showed that they could not have come from Shap fells at all; that there were almost insuperable difficulties in the way of the belief that any masses of great boulders could have come from Shap and be scattered over the plains of Lancashire. The para-

graph was as follows:—"Dr. Buckland held the opinion that the granite boulders of the Shap district had been carried southwards by glaciers, and deposited by their agency over the Midland counties; but the writer was not able to find the same evidences of glacial action in the Shap fells as those which exist in West Cumberland. The granite district of Shap is limited to an area of some 800 to 1000 acres, comprising Wasdale Pike, about two miles above the Shap Wells House. Wasdale Pike is not an isolated peak, but is an outlier of the mountain range at the head of Troutbeck, of which Tarn Crag forms the central summit. The valley below the Pike and thence over the whole of Shap fells has a most remarkable aspect, from the large numbers of immense rounded masses of granite which are everywhere scattered. These widely-dispersed boulders cannot altogether be accounted for by the agency of glaciers. The summit of Wasdale Pike is only 1853 feet above the sea, and the valley at its base some 500 feet lower, and the junction of Wasdale Beck with the Lune at Tebay is but 700 feet above the sea; so that it scarcely appears probable that any glacier could be continuous to such a point as would admit of its transporting its moraines to the sea, where they could be carried away and dispersed by drift ice. Another explanation must be sought, and it will probably be found in the very fact of the occurrence of this solitary peak of granite. The whole district abounds in intrusive veins of Whinstone and other Plutonic rocks, crowned by the granite peak of Wasdale Pike, which has evidently been forced up through the slates by some volcanic force, and this might produce the tremendous effects which scattered these blocks far and wide. The denudations here have been on a tremendous scale, and possibly carried the granite boulders far down the Lune valley, and formed the moraine-like mounds, referred to by Dr. Buckland, near Milnthorpe

and Lancaster, at which points possibly drift ice became the modifying and transporting agent."

The CHAIRMAN said with regard to finding Shap granite in Lancashire, that some years ago he, in company with Professor W. B. Dawkins and Mr. James Eccles, picked up a pebble of this rock near the banks of the river Ribble, a little north of Preston; and that more recently he had personally collected a number on the sea shore at Hest Bank. They were generally small and might be termed mere pebbles, and he had some in his collection now, so that they did find their way to Lancashire. If Mr. Brockbank confined himself to large masses or boulders he might be right.

Mr. BROCKBANK: Any quantity has come down the Lune.

The CHAIRMAN: I understood you to say that none had been found in Lancashire.

Mr. BROCKBANK: In the boulder drift; in elevated positions.

Mr. CROFTON reminded the meeting that he had stated at the outset that he had nothing new to advance. He had simply, at the Secretary's request, placed together the notes of his visit to the district in question.

ON INCRUSTATION AND DEPOSITS IN STEAM BOILERS.

BY MR. W. J. GRIMSHAW, F.G.S.

The following notes do not purport to be a comprehensive statement of the nature and qualities of known natural waters, but rather an account of the action of a few of them, on the internal parts of steam boilers. Very few people who have had steam boilers under their supervision have been fortunate enough to escape trouble caused by the feed

water, and more especially must this trouble have been experienced by those in charge of colliery boilers, which it is oftentimes needful to feed with "mine" or mineralised water, simply because no unpolluted supply is available. The "mine" water has in many cases been so troublesome, and has caused so much direct and indirect expense, that the use of water supplied by some town or district water works company, notwithstanding its price, has often resulted in a very considerable saving.

All known natural waters hold in suspension or solution various solid matters. Matter held in suspension may be got rid of by adequate means of filtration. In theory this is well enough, but in practice it is an extremely difficult undertaking. Filters are combined with feed water heaters in many cases, and certainly they do some good, although far from perfect. Any approximately perfect method of filtration would be very expensive in the great majority of cases, and relatively the cost would be altogether disproportionate to the work required to be done. Purifying the water before it enters the boiler being practically impossible, Mr. Anthony Scott, so long ago as 1827, partially reversed the process, and filtered the water after it had entered the boiler.

This he effected by placing in various portions of the boiler trays or shelves, which acted as receivers of the matters held in suspension. In these trays the water does not boil, and the greater the agitation of the water the greater proportionate quantity of sediment settles in them. These trays were eventually made self-cleansing, without interfering with the duty of the boiler.

Calcareous incrustations are more difficult to deal with than sedimentary deposits. These incrustations vary very much in their constituents, but generally contain either carbonate or sulphate of lime in considerable proportions.

Both these substances are difficult to deal with. It is no use trying haphazard remedies on the chance of hitting upon a right one, for the same process which acts successfully where one water is used may be utterly useless, or even positively harmful, where a seemingly similar water, perhaps obtained from the same strata or measures, is used. The safest plan is to have the water analysed, and obtain instructions from the analyst. Sometimes the application of the remedial agents requires such delicacy and care, that an ordinary workman can hardly be expected to attend to it. The generally adopted means of dealing with calcareous incrustations may be found in most manuals referring to steam boilers, so I need not here recapitulate them.

Water from collieries in working, or that have been worked, necessarily flows upon the floor of the mine or mines. In many instances it makes its way under a solid barrier of coal, in the thill. The writer has known a case of water standing against a barrier of 300 yards making its appearance in the thill on the lower side thereof, while the coal face and roof seemed perfectly dry. Water that has passed over or through thill generally deposits a fine sediment that does not cake or crystallize. This sediment naturally rests on the top of the flues and the bottom of the boiler. It is a good non-conductor of heat, and, consequently, the flues get red-hot in a comparatively short time. When the boiler is blown off, all the inside is coated with it, like whitewash, and it has to be swept off when dry. This substance contains silicate of magnesia and a small quantity of lime, and, as far as the writer is aware, nothing is known that will dissolve it, without injuring materially the iron of the boiler. Nitric acid will dissolve it, and sulphuric acid will dissolve it very slowly. The only feasible remedy seems to be, a change of water.

Water coming in contact with iron pyrites generally contains a proportion of sulphuric acid. The best defence against this, is the infusion of caustic soda, thus forming sulphate of soda, which does no harm; having an alkaline base. All soda compounds are soluble in water.

It is by no means advisable to use hot well water from condensing engines to feed boilers, for the tallow, &c., used for the engines finds its way there, and consequently goes into the boilers. If there be lime in the water in the boilers, the tallow decomposes and forms an insoluble lime "soap." This "soap" is as sticky as birdlime, and coats the bottoms of the boilers and flues. Being a good non-conductor the flues soon burn through. If "hot-well" water is used, as much caustic soda ought to be put in the boilers as would suffice to take up the quantity of tallow used for engines. Tallow is composed of margaric acid and oleic acid, which uniting with lime form margarate of lime.

Acid water attacks zinc or any bright metal much more readily than its does iron, showing that some saving may be affected by placing zinc plates in the interior of the boiler.

Muriate of tin is manufactured in shallow iron pans, by pouring muriatic acid on granulated tin. As long as there is an excess of tin, the iron is comparatively uninjured. Placing zinc plates in boilers is simply following up this principle. In many cases in Germany, more especially where the water contains lime, these plates are connected by means of wires, with a Bunsen or Sand battery. The electrical action prevents the foreign matter contained in the water from caking, and throws it down in a sediment which is got rid of by means of scummers, &c. The tendency of galvanic action is to precipitate insoluble matter in a finely divided state. The writer is not aware that this method is adopted in this country, but it certainly seems worth a trial, the needful apparatus being comparatively nexpensive and the attachment easy.

Waters obtained from the same source differ in composition at different times, and more especially is this the case with pit waters, raised from a mine or mines in course of working. If the feed water is obtained from old workings, it does not differ much in quality, being as a rule as bad as it can well be.

The best remedy for bad feed water, is to obtain better, and though the cost of so doing may appear excessive in many cases, it generally pays well in the end. The writer is strongly of opinion that many people have no adequate conception of the saving to be affected by using good feed water, or where good is not obtainable, the best that can be got.

Mr. Peter Spence said that for several years he had great difficulty in his efforts to prevent the incrustation inside his boilers, but after making several experiments he discovered that no deposit but what could be easily blown or swept out was made if the water was rendered sufficiently alkaline. His boilers are fed from the Rochdale canal, and the water in the boilers is tested daily, by dipping a piece of litmus paper in some which is drawn off from each boiler for the purpose, and if not alkaline enough he put in some carbonate of soda or soda ash. The result was that he had not chipped a boiler for the last 12 or 15 years. An evil that had in some cases to be dreaded was the water supply being impregnated with sulphuric or other acid, which corroded the boilers, but this also was completely cured by using soda ash. He knew that impure water was a troublesome and dangerous thing, but he believed all waters containing sulphate of lime would be cured by the remedy he had suggested.

Mr. Dickinson said that he wished, on this occasion, to testify to the great advantages which the boiler insurance

and inspection companies had conferred on the community in general, by the knowledge they had imparted in regard to the working of steam boilers.

The CHAIRMAN said he would like to ask what effect peat water had upon boilers.

Mr. GRIMSHAW replied, that he had only seen it used in one case, and some effect was produced, but he had not had sufficient experience with this class of water to give an opinion.

The CHAIRMAN said that the boilers under his control were supplied with water strongly impregnated with peat colouring matter, but it did not act injuriously upon the boilers. They had two that had been in use fourteen or fifteen years, and with the exception of some deposit, the iron seemed almost as good as when the boilers were put in, and he attributed that to the action of the peat.

Mr. SPENCE did not think peat water would make any deposit. Lime was the great evil that had to be contended with.

The CHAIRMAN wished to know if peat acted as a preservative.

Mr. SPENCE said it might be, but when the water was in an akaline condition it had a preserving effect. The soda seemed to throw down the lime in a form that would not coat on the boilers. It lay as a sludge at the bottom, and all they had to do, was to take a broom and sweep it out. He therefore said to all people who were bothered with their boilers, make your water alkaline and blow off the sludge.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XV. SESSION 1879-80.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 16th day of December, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKEN, Esq., Vice-President,
in the Chair.

M. Theophile Guibal, Government School of Mines, Mons, Belgium, was elected an honorary member of the Society. Mr. Charles Pilkington, of Haydock, Ashton, and Edge Green Collieries, St. Helen's, was elected an ordinary member.

UPON THE ARRANGEMENT OF A GEOLOGICAL MUSEUM.

BY ROOKE PENNINGTON, F.G.S.

The importance of museums is becoming recognised by the public. Books alone cannot teach science or cultivate a taste for art; whilst, on the other hand, the vast majority of students have neither means or leisure to make collections of their own or to visit those of private individuals. As public libraries are necessary for the popular cultivation of literature, so in even a greater degree are public museums necessary for the cultivation of science and art. Confining one's attention to that branch of science known as Geology, the help of a

museum is as indispensable as pencil or brush to the student of painting. He to whom command of time and money gives the power of extended travel can no doubt learn much; but even then he can only gain a smattering of the history of ancient life, if he lacks the aid of a well arranged series of specimens, and as the value of these specimens depends very largely upon the manner of their arrangement, their due order is well worth the attention of all who are interested in extending as widely as possible a knowledge of science. It is a matter of regret that it should be absolutely necessary in science to employ terms which are not easily understood, and which frequently require considerable attention on the part of the student before he realizes their exact meaning. It is therefore a point of considerable importance a point to which perhaps sufficient attention has not been so far directed, to consider the best means of grouping the various specimens necessary to teach the science of geology, and at the same time to explain the names by which amongst those versed in science they are known. I feel considerable diffidence in submitting any definite scheme of arrangement to the Society as I have no claim to speak with authority. I confine myself entirely to considering the arrangement of a geological collection, although I believe that many of the principles which will ultimately be laid down will be found applicable to series of specimens illustrating other sciences.

Until recently, with a few notable exceptions, local museums were ill-arranged lumber rooms. Everything which was worthless to its owner and had the smallest claim to be considered a curiosity was presented to the nearest collection. Many so-called museums have not yet advanced beyond this point. Within the last few weeks I have seen gravely recorded in local newspapers thanks from Town Council Committees to the donor of such a miscellaneous lot of rubbish as the snout of a sword-fish, a Chartist medal, a

large goose-egg, a piece of stone from Temple Bar, a sword used at Waterloo, an ammonite from the coal measures, a fossil cockle from ditto, some copper coins, and a bear's paw. And even museums under the control of managers whose scientific knowledge is sufficient to exonerate them from all suspicion of being mere popularity hunters, and who have either been untrammelled by the rules of Town Councils or have had sufficient confidence reposed in them by such bodies as to make them practically supreme, have still contained valuable series of objects exhibited rather in honour of the donors than in elucidation of science. Instead of distributing specimens according to genus or stratum, a series of Silurian fossils, Philippine Island shells, and Wedgwood medallions will be found exhibited together in one case in memory of some local collector. Interesting as a record of industry and observation, such a set is, of course, useless for any valuable purpose.

Indeed, the Curator of a collection worth the name of a museum must exercise despotic control over arrangements, and must ruthlessly exclude mere curiosities. There are two ways of doing this, but if he exercises his prerogative with tact he will not stop the flow of liberality, and at the same time he will keep out rubbish. Assuming therefore that a system must be adopted and adhered to, upon what basis should it be founded. The first consideration is the sort of building best adapted for the purpose. Plenty of wall space and plenty of light are the two essentials, and perhaps the nearer you can approach to an ordinary weaving shed the better building for museum purposes you will get. As however the nature of the building must vary according to circumstances, it would not be of much advantage to endeavour to lay down a general principle beyond this—that the ends of the curator should predominate over the aspirations of the architect.

Coming to the immediate subject of the paper, I have had in view a principle in limiting its scope to the arrangement of a scientific collection. It is true that here and there there may be found scientific objects more or less dovetailed into excellent series of art illustrations. Some people have entertained a delusive hope of seeing huge collections which might illustrate the growth of modern art from that of our mediæval ancestors, the development of their art from the rude beginnings of the pre-historic races, that by the linking of these long forgotten peoples with the geological periods which preceded them, a continuous chain representing the history of life on the earth might be presented to the admiring student. The connection between an "Eozoon," if ever such a creature existed, and a picture by Millais, is perhaps somewhat too broken to be of much service, nor do I think that an admirer of the old masters, or even a student of hieroglyphics would reap much advantage from a knowledge of Triassic marsupials or Silurian crustaceæ. In fact, as a rule, the description of mind which is best adapted for the arrangement of art specimens does not possess that mathematical precision which should be applied to science, and even where a curator can be found who happily combines the two powers, he will be liable to antagonistic directions from two divisions of the managing body, and the commencement of history, roughly speaking, marks off a naturally sharp dividing line between the two series of objects. Nowhere have we as yet traced a home growth from barbarism to civilization. Everywhere at a point generally about co-incident with the beginning of history, we have the incoming of a vastly superior social condition brought from a foreign source. Thus the villa of Carausius is in no way a development from the hut-circles of the brave men who lived on our moorlands before Cæsar. There is no continuity. The wigwam is pure British, the

villa is entirely Roman. The one is no more the progenitor of the other than the rifle of the Maori of to-day is the outgrowth of the Patoo-Patoo of his ancestor who witnessed the landing of Captain Cook. It seems to me, therefore, that a geological collection should end with illustrating the subordinate science of pre-historic archæology. It should, however, include this partly in regard to the historical dividing line I have above mentioned, and partly because the articles upon which archæology is founded are largely obtained from deposits which are regularly classified by the geologist; from those, in fact, known to him as "Recent." With these illustrations of the latest geological deposits, and as admirably illustrating their significance, a small and characteristic ethnological series might be advantageously combined. It is from the savages of to-day and of the last century that we have learnt with a considerable approach to certainty what was the social condition of our predecessors who used the bronze and stone implements which the geological strata, together with numerous caves and burial mounds, have yielded to us. The main principles which should guide an arrangement should, I would suggest, be as follows:—

1. Never assume that those who examine the collection understand the science to be illustrated. Those who do will not be inconvenienced by efforts to explain things to those who do not, while the latter will be greatly assisted. It is, of course, impossible to teach geology by the mere inspection of a collection, however elaborate the explanations may be. This principle must therefore be modified by limiting it to the elucidation of a few simple points which may lead the visitor to enquire further into the matter and so to become a real student of the science.

2. Arrange the collection in its proper geological order, that is, let each group of fossils be arranged both strata-

graphically and according to kingdoms, families, genera, and species.

3. Use popular names wherever possible, as well as scientific terms, that is, wherever a fossil is allied to a living representative possessing a popular name, let that popular name with any necessary qualifications be attached to the ordinary scientific name of the fossil.

4. Use every fair device to make visitors realize the nature of the thing—stony remains of which they are examining, and generally strive to render the collection popular. Without sacrificing accuracy you may easily preserve simplicity. Do not err on the side of severity, the object should be to cater for the multitude, and the arts of catching the attention should not be left unused.

Many other rules subordinate to these might be suggested. A few of these may, I think, be advantageously indicated. Beginning at the latest period which the collection is intended to illustrate, a short and clear explanation of the terms "Bronze Age" and "Neolithic Age" should be attached to each case of specimens contributed to this period.

Although (unless archæologists have so far altogether miscalculated the relative length of periods) the majority of prehistoric traces in England belong to the Neolithic time, yet, from the nature of the evidence, this cannot be proved to demonstration. Have, therefore, some Swiss and Danish specimens to mark clearly the difference between the bronze and stone ages. The articles from each cave or tumulus may be advantageously grouped together: the weapons of the ancient savage will show his savagery; his ornaments, his pottery, and the bones of the creatures he ate will show the advance he had made, whilst a reference to the cases containing Palæolithic relics will lead the student to realize the enormous difference between the two epochs.

Pencil and brush should be freely used here, a restoration

of a Swiss lake dwelling, a Danish gallery grave, and a drawing of a stone circle will greatly help the visitor. As the majority of visitors will have but a dim notion of a tumulus or grave-mound, let there be a sketch of one, with a section showing interments in situ, whilst near it may be placed a cinerary urn with its contents carefully arranged, and, close at hand, there may be a short printed description or explanation. One such urn and its contents so arranged and described will teach more than fifty labelled in the ordinary way.

Coming to the Pleistocene period, it may be found advantageous to interpose between the Neolithic period and the human relics of this earlier epoch a series of the animal remains of the period. In my collection at Castleton I have arranged the whole of the bison, bear, and reindeer specimens, obtained from Windy Knoll (which probably represents a rather later portion of the Pleistocene period), and also the rhinoceros, hyæna, mammoth, bison, horse, bear, and lion remains from Cresswell and other northern localities, in a position intermediate between the remains of the cave men and of the men whose implements are found in river gravels and those of the later prehistoric peoples. With these relics of Palæolithic man a few of those implements of the Palæolithic type which have been obtained from recent savages may be introduced with a proper description. Whether the supposed identification of some of the cave men with the Esquimaux is anything more than a guess is not a matter for present discussion, but the resemblance of Palæolithic implements and drawings to those of the Arctic people, also (strangely enough) to certain of the South Sea Islanders, will serve to convey vividly to the mind of the visitor the incontestably human origin of these ancient weapons.

Referring for a moment, again, to the Neolithic period, I

have noticed that many people who were incredulous as to the artificial character of many flint scrapers have been convinced on this point by being shown such an implement, quite as rude in its fashioning as most of those picked up on our hills and downs, which had been obtained from one of the Swiss lake dwellings, and was still in its original wooden hafting.

With respect to what is more ordinarily known as a geological collection, there is here even more need of ingenuity in order to make the student realize the bearing of the specimens upon existing types of life. A few pen and ink sketchings or water colour drawings showing what extinct creatures probably were like, will be found a great assistance. These may be easily introduced into the case without occupying very much space. Restorations of a mastodon, a machairodus, an icthyosaurus, a pterodactyle, an apiocrinite will serve as examples. A sketch of a mammoth, a plaster figure of a cheirotherium, a drawing of an Irish elk, will teach most people far more than any number of *Sesquipedalia verba*. Again, wherever it is possible, particularly with respect to the mollusca, a recent shell might be placed in the case side by side with the fossil. To take one or two familiar examples, he who sees a mactra or a tellina or a turritella, such as may be picked up on British shores, or a conus or a volute from the Indian seas, side by side with a Pleiocene or Eocene fossil, will probably realize far more clearly that the fossil was originally the envelope of a living creature than he would do had he no such recent assistance afforded him. This assistance need not be limited to tertiary forms, but may be extended by ingenuity almost to the earliest strata. An Australian trigonia side by side with an oolitic trigonia is an instance. Even where it is difficult or impossible to supply this aid, clearly printed labels should be freely supplied, either describing the nature

of the creature or suggesting, if not actually exhibiting, some living analogue. For instance, an ordinary visitor will get but little information from the name "beryx" attached to a specimen, but it will possess a new interest for him if he is told that the fossil is one of a fish not unlike a perch. Let him know that a hipparion was a first cousin to the horse, that a spatangus was a sea urchin, a belemnite the bony interior of a cuttle fish, and so on. Throughout the collection the student should be reminded that there were differences of temperature and conditions of life over the surface of the globe in former geological periods, just as at present, and that fossils from various regions may be the relics of contemporaneous life, although widely differing one from another. For example, the greater warmth of the meiocene period as compared with that of the present time in Europe may be noted, and the names of the various genera of trees which then flourished in Switzerland and other parts may be freely translated, in order that the visitor may compare them with the vegetation of warmer climates to-day. Similarly, the meiocene, carboniferous, and silurian fossils discovered in the polar regions may be brought into prominence for the purpose of fixing in the memory a very important fact, which even able geologists are, perhaps, too prone to overlook when they confine their attention too stedfastly to one limited district. No space will be taken up, but very useful lessons may be taught by attaching to the tablets upon which specimens are mounted a note of their range in time. I need hardly say that the zoological order of the fossil belonging to various formations should be indicated. I am not quite certain that this is best done by different coloured tablets or by labels attached to each group. I rather incline to the latter mode, because the former implies an effort of the memory as to the colour denoting each family which I think it is, perhaps, unwise to demand

from the average visitor. If the name of each family is placed in juxta-position with the group of fossils belonging to it, no great amount of room need be taken up, and the indication is ever present. Similarly, the habitat of the creature, that is, whether it is a marine, freshwater, or land animal, may be easily denoted by a small slip affixed to each specimen or its tablet. Here and there short accounts of the differences between allied and frequently occurring forms may be given in clear terms; as for example, the resemblances and distinctions between a terebratula and a rhynchonella, a spirifer and a productus, a nautilus, ammonite, goniatite, and belemnite.

Casts of the rarer fossils should supplement the common species, and a few of the principal stratified rocks may be placed near their appropriate fossils.

It is no part of my intention to discuss the best sort of cases or the best sort of tablets in which to arrange specimens. I have rather desired to call attention to what seems to me, broadly speaking, to be an almost neglected art. We have in the country numerous admirable curators each bent upon an exhibition and arrangement of the specimens under their charge in the best possible manner. I hope I shall not be considered to have been in anyway wanting in deference to those who have had so much more experience than myself, but it does seem to me that it is desirable, in the first place, that, if possible, some uniform mode of arrangement should be decided upon, a mode at any rate as uniform as can be according to the varying designs of teachers, and further, that, in any case, public discussion and criticism as to museums may be advantageously applied. I venture to hope that the curators of the various museums in this district will not consider that there is any infraction of their dignity in listening to and considering what students most desire and want. We have had of late years a considerable amount of

public attention directed to the best mode of conducting that companion of a museum, the Library. The main object of arranging a library well is to give each student the greatest facility for getting the book he wants to read. When, as in a museum, the book has frequently to be read and even interpreted to him, its conduct becomes a matter requiring even greater attention than the grouping of the volumes under a librarian's charge.

Professor BOYD DAWKINS said: I have listened with very great satisfaction to what has fallen from Mr. Pennington's lips, and I have entire sympathy with those expressions of scorn to which he has treated us with regard to the usual condition of museums in this country. I quite believe, with him, that the only complete and proper museum which should be is of that kind which he has put before us so exceedingly well; and I would even go further than he has gone in this matter. I do not know anything more likely to prove that we are behind the rest of the world in scientific pursuits, so far as the general mass of the people goes, than the condition of the museums in this country as compared with those elsewhere. The museum Mr. Pennington has sketched to us is to a very large extent a pure ideal, so far as relates to this country. As far as I know it has only been attempted in one little place, Castleton, and it has not been perfectly realised even there. It is absolutely impossible for any one individual to get together a sufficiently large collection of things to illustrate the whole history of nature. In this country, so far as I know, there is no natural history museum which gives us a picture of nature even in outline. If, however, I go to places such as New York, I do find a certain attempt at it. If I go to the principal cities in Europe I find large and well-arranged museums, and to a very considerable extent properly labelled,

—although, perhaps, the names are rather too long. In this country, and in this place—which is the place of all others where, in the centre of wealth and commerce, we have better opportunities of getting together materials for a good museum than exist elsewhere—we have not a single museum which is worthy of the name, if we use it in the sense in which Mr. Pennington has used it in relation to his ideal. So much for the condition of museums at the present time. With regard to the classification he has pursued I entirely sympathise with it. I would say that the geological period extends down to the present moment—to this very time in which we are assembled in this room—and that no hard and fast line can be drawn between the beginning of the Tertiary period and that period in which we are now living. Therefore, I feel certain in a geological museum we shall have to bring the history of things down to the present time. But although that be so, of course it is perfectly true that the classification of pictures and works of art—statues and so on—cannot, in the very nature of things, have any position in a museum which is founded to represent natural history, and not the history of art. Nature is one thing and art is another; and although they do, to some extent, interlace and overlap, yet you must, if you want to really teach either art or science, keep the two separate. I therefore entirely agree with what has fallen from my friend Mr. Pennington.

Mr. JOHN PLANT said that the greatest puzzle to his mind was, why such a paper as that of Mr. Pennington's should have been read to this Geological and Mining Society, which no longer had control of a museum. The paper, however, had been read; and if he had not, in the course of 35 years' experience, read the same things many times, he might have been struck by the novelty that it presented. As it was, he was used to this; he possessed a dozen or so such lectures

of advice, what to do in museum arrangement.* They contained a great deal more theory than practice, always as it were criticising or censuring somebody or other for not doing some thing which was not done, or for doing that which was done. In museums the best thing for managers was to make the most of their opportunities. Those opportunities they could not create without funds, and they knew that large museums—say the Jermyn Street Museum—had to be curtailed in what its directors would consider to be a moderate limit of their own ideal, by Parliament refusing to grant them lavish funds. He did not know any institution, whether governmental or municipal, or belonging to educational foundations like The Owens College, or private museums like the one at Castleton, which were not limited by want of money, and prevented from doing much which they would like to see done. As to our English museums, which were said by Prof. Dawkins to be so deficient in interest, he could only say that they were visited by intelligent foreigners, and—so far as his own experience went—he had never listened to words of detraction from the lips of such visitors; on the contrary he was proud to say that official opinions had been printed abroad, showing that they could not do better than copy the admirable museums and institutions which existed in Great Britain. He did not deny that certain municipalities in France and Germany possessed museums largely aided by their Governments; he could say, as far as this country was concerned that opportunities were not lost, to the extent of the means afforded, of acquiring objects of interest and value; we could not expect, in Manchester, ever to possess

* 1. Forbes, Professor E.: On the Educational Uses of Museums; pp. 19; 1853; printed by the Board of Trade. 2. Wallace, Alfred, F.R.G.S.: On Museums for the People; Macmillan; 1869. 3. Solly, Ed.: Museums, their Nature and Uses; pp. 16; 1853. 4. Charlesworth, E., F.G.S.: On the Arrangement of Museums, applied to the Derby Museum; a pamphlet; and others.

a fine series of the fossils which belong to the south east, or the north east of Great Britain, but we could at least expect, and did in fact realize, the collection and preservation of objects which were local and more directly interesting to ourselves. In no other museum in Great Britain would they find so large a number of the fossils of the coal measures or of the Palæozoic period as were to be seen in the Manchester, Liverpool, and other northern museums. . As to Mr. Pennington's views, it is right that everyone should exercise his own notions about the arrangement of a museum. If he had the time or could spend the money to carry out his hobby it was perfectly right he should do so, but if he thought that he could impress any body of men like a committee of a Town Council with any crotchet which he or anybody else possessed, he was much mistaken. Town Councils asserted independent authority over the management of their own museums, and we must credit them with a desire to do the best for the institutions under their charge. But to offer advice to committees which they never asked, to tell them that everything done was inferior to something done elsewhere, would be a very wrong way of bringing about any reform or improvement in their museums or libraries.

Mr. MARTIN (Hon. Sec.) said he certainly could not agree with Mr. Plant that the paper was out of place before this Society. He thought it would interest a majority of the members.

Mr. PENNINGTON said, with respect to his paper coming within the scope of that Society's operations, he could not conceive any better subject to be placed before a Geological Society than a spread of the knowledge of geology, and that could only be done by the proper arrangement and popularising of museums. As to the novelty of his views, he was not prepared to enter into any contest with Mr. Plant. He was not aware of those numerous works to which Mr. Plant had

referred; he would have been only too glad to have been acquainted with them, but must confess his ignorance. Certain he was, however antiquated those views might be, they had not produced any reform of museums in this country, such as *might have been expected* if expounded by eminent men *so many* years ago. He must disclaim the slightest intention of reflecting on the museum with which Mr. Plant was connected. He believed, from what he knew of it, that it was doing good work, but whether it was arranged in the way he (Mr. Pennington) would suggest was altogether another matter. Mr. Plant might have his own opinion, as Mr. Dawkins had his, as to the best way of carrying out the work in which he was engaged. He could only say, further, that there was not a word in his paper which could fairly be construed as an attempt to lecture either Town Councils or anybody else. Town Councils certainly ought to be amenable, perhaps more than other people, to public criticism, and the more public criticism and thought could be devoted to the question of the proper arrangement of museums, the better it would be for the rising generation, as far as their education in geological science went.

ON THE DISCOVERY OF AN ANCIENT IRONMINE IN CLIVIGER, AND SOME FURTHER REMARKS ON THE REMAINS OF OLD BLOOMARIES IN THE NEIGHBOURHOOD OF TODMORDEN.

By Mr. John Aitken.

At the meeting held here on the 27th of May last, I drew the attention of the Society to a bed of iron pyrites which had recently been discovered in the millstone grit, in the Walsden valley, near to the remains of an ancient bloomary,

from whence I ventured to suggest that ore had probably been procured to supply not only this old furnace, but also others which formerly existed in that locality.

During the discussion which ensued doubts were expressed as to the suitability of the iron pyrites—specimens of which were exhibited—for the manufacture of iron in sufficient quantity and quality as to render its use a remunerative undertaking. My object, on that occasion, being rather to bring the subject before the meeting in the form of a suggestion, which seemed to me to offer a probable solution of an existing difficulty than as the assertion of an indisputable scientific fact.

Since the reading of that paper I have continued my investigations in the neighbourhood with the view of either confirming my former suggestion, or of finding out some more satisfactory answer to the perplexing question as to where the ore came from to supply these old bloomaries, and I have now to state that my efforts have been rewarded by obtaining evidence bearing upon it, which I feel confident will offer a satisfactory solution of the matter, and remove the difficulty which has hitherto surrounded it.

This consists in the discovery of an old disused ironstone mine, which has been wrought on an extensive scale at a very remote period, and from whence a large quantity of ore must have been extracted, the date at which it was used being so distant that the entrances to it had become completely blocked up, and concealed from view, and its very existence almost forgotten in the district.

The situation of this mine is in the Cliviger valley (a deep rocky gorge running from Todmorden to Burnley, about half way between the two towns, and close to the summit, where the twin rivers, Calder, take their rise) in a steep escarpment, on the north easterly side of the valley, known as Ruddle Scout.

The workings as already stated, are of considerable extent, consisting of a series of long drifts or chambers driven into the side of the hill, from whence side workings were set off. The refuse shale having been disposed of—as far as possible—in the old drifts after the extraction of the ore, and the remainder discharged down the face of the cliff, into the vale below, thus forming large spoil heaps opposite the several entrances. The works appear to have been set out and conducted with fair skill. Most of the main roads are still open, and may be traversed for considerable distances at the present time, their preservation being attributable to the character of the roof, which consists of a platy fine grit rock, and the prudence of the ancient miners in leaving as supports either portions of the undisturbed strata, or when removed by building up strong sustaining walls, in consequence of which the mine may be explored and the workings examined over a considerable area, the furthest points reached being upwards of 300 feet from the entrance, when further progress was arrested by standing water in one direction, and by a falling of the roof in others.

The roads—where in their normal condition—are about four feet high and four feet wide, the side workings being generally set off at right angles to the main roads, and appear to have been driven of various widths ranging from four to ten feet.

The bands of ironstone are very variable, ranging from one to four in number, and from half-inch to five or six inches in thickness, and are also found at various levels. The uppermost seam, which occurs generally a few inches below the roof rock, is, however, the most regular and persistent, and is also the thickest in the series.

The following three sections, taken at different parts of the mine, will illustrate this fact :—

No. 1 SECTION *(taken in North Road).*

Roof rock—flaggy sandstone.	ft.	in.
Black laminated shale...	0	6
Ironstone, from four to six inches	0	5
Black laminated shale...	1	6
Ironstone, from one to two inches	0	2
Black shale	1	6
	4	1

No. 2 SECTION *(taken in one of the workings).*

Roof rock—flaggy sandstone.	ft.	in.
Black laminated shale...	0	2
Ironstone, in two layers, separated by a thin parting of shale	0	6
Black shale	3	6
	4	2

No. 3 SECTION *(in S.W. working.)*

Roof rock—flaggy sandstone.	ft.	in.
Black laminated shale...	0	3
Ironstone	0	3
Black laminated shale...	0	6
Ironstone	0	1½
Shale	0	8
Ironstone	0	1½
Shale	0	10
Ironstone	0	0½
Shale	1	4
	4	1½

From these particulars it will be perceived that the aggregate thickness of ironstone only reaches about six and a half inches.

It is somewhat remarkable that so small a proportion of ironstone to the quantity of shale removed should have possessed sufficient value to ensure its being economically pursued. From the fact, however, of its having been worked on an extensive scale,—which must represent a lengthened period of active operations,—leaves no room for doubt that it was so, and leads also to the further inference that ironstone was at that time a scarce material and difficult of attainment, thus giving to these attenuated bands a value they would not have otherwise possessed.

In this respect, however, no material difference exists when compared with the celebrated Low Moor measures, where three feet five inches of strata only yield six inches of ironstone, in four bands as follows:—

Roof.	ft.	in.
Shale	0	2
Ironstone nodules	0	2
Shale	0	8
Ironstone nodules	0	0½
Shale	0	11½
Ironstone nodules	0	2
Shale	1	1½
Ironstone nodules	0	1½
	3	5

Yet these mines have continued to be profitably worked for a century at least, and, in all probability, for a much longer period.

As will be seen by reference to the section appended hereto, the Arley Mine occupies a position only a few feet above the bed of shale in which the ironstone occurs. This important seam of coal formerly extended over the area overlying the ironstone measures, at from twenty to forty feet beneath the surface. Immediately overlying the coal is a

bed of grey shale five feet in thickness, having a number of ironstone nodules running through it. The surface dips in conformity with the underlying strata, at an angle of 12°, so that the coal is reached at a nearly uniform depth. Advantage has been taken of its proximity to the surface for extracting the coal by means of shallow surface sinkings. These shafts stud the area in question in great numbers, and give to it a very singular appearance, 120 to 150 having been noticed. At the present time they generally consist of a central hollow, from four to ten feet deep, with a low encircling rampart, doubtless derived from the refuse matter brought up in sinking the shafts and getting the coal. The seam appears to have been completely removed and the superincumbent beds let down on to the seat earth below, as a careful examination of the section exposed on the side of the escarpment has not resulted in bringing to light any trace of the coal in situ; small detached pieces may, however, be picked up in plenty about the old shafts. If the coal were raised at the same time the iron-mining operations were being conducted, doubtless the ironstone balls contained in the roof shale would be utilized, and that they were so is rendered probable from the fact that they appear now to be absent from the old spoil heaps.* If this assumption be correct, the aggregate quantity of ironstone would receive a sensible increase.

The ore does not appear to have been smelted in the immediate neighbourhood of the mine, as no bloomaries are known to have existed in the Cliviger Valley; the nearest known sites being those in Walsden, referred to in my former paper, those in Dulesgate and the Rossendale Valley, described by Mr. James Kerr,† and two in the Hebden

* The coal may have been used for roasting the ore before removal to some other place for the purpose of being smelted.

† On the remains of some old Bloomaries formerly existing in Lancashire.

Valley, near Hebden Bridge, the last-named of which have not, I believe, yet been described. None of these are more than seven miles from this old mine, whilst some of them do not exceed three. The probable reason why no bloomaries were erected in Cliviger was the want of fuel. Very little or no old original timber is found in this gorge, and I have the authority of Mr. Abraham Stansfield, of Todmorden, for stating that there is no appearance of its ever having produced such in quantity sufficient for this purpose; hence the necessity of conveying the ironstone to other places where this desideratum existed, as it was found much more economical to take the ore to the fuel than carry the timber necessary to supply the furnaces where the ironstone was procured.

It would however appear, from the large accumulations of burnt shale of a brick-red colour, together with numbers of pieces of roasted ore which occur in close contiguity to the mine, and notably so on the elevation immediately above the principal entrances, that the iron was calcined before removal —the body of burnt shale having been so considerable as to have given a character to the top of the escarpment so marked as to have earned for it the name of Ruddle Scout.*

The layers of ironstone consist of irregular concretionary or nodular bodies—and not in regular platy bands—each piece being, as a rule, separated by a layer of shale from the one nearest to it, from which it differs in size, form and thickness; they are, nevertheless, generally arranged in lines more or less regular for varying distances, when they die out, and are replaced by other bands at different levels, the uppermost one, however, as already stated, being much more

* Rud being the Saxon for red; Ruddle being applied to red earth coloured with oxide of iron; and Scout being the Norman for a high rock. It follows that the name Ruddle Scout denotes a rocky declivity surmounted by a body of red ferruginous matter.

regular and persistent than the rest. These bands can be readily traced along the sides of the old workings from the fact of the faces of the fractured nodules presenting white surfaces, arising from the presence of thin layers of carbonate of lime, which appears to have been deposited in fine cracks or lines of weakness, something after the fashion of septaria. The stratigraphical position of the ironstone beds will be understood by reference to the annexed section, taken from the Memoirs of the Geological Survey*, which accords very closely with my own observations.

SECTION RUDDLE SCOUT.

	ft.	in.
Grey shale with six ironstone bands...	17	0
Black shale with ironstone balls	5	6
Grey shale roof	3	6
Coal, Arley Mine, Cliviger	4	0
Seat clay, with two bands of coal ...	5	0
Sandstone (Ruddle Scout)	9	0
Black shale, with ironstone (old mine)	3	6
Hard brown sandstone and flags	19	6
Grey shale (grey layers)	25	0

Through the kindness of Peter Spence, Esq., who has taken the trouble to analyse the ironstone, and also a piece of the scoriæ obtained from the old bloomary at Bottomley Brook, in Walsden, I am enabled to give the following particulars, viz.: "The ironstone is a carbonate of iron, and contains 39·20 per cent. of metallic iron," thus proving richer than the Low Moor Black Band to the extent of 9·20 per cent., which latter only yields 30 per cent. of iron, or, in other words, to produce one ton of iron 67 cwt. of the raw stone has to be used.

It is well known that the rude method of smelting by means of the old open air furnace, especially when the ore

* The Geology of the Burnley Coal Field.

happened to be of a somewhat refractory character, such as clay ironstone usually is, the extraction of the iron was very imperfectly accomplished, so much so that "at Low Moor and other places it has been found remunerative to re-smelt the old slag."* I was not, however, prepared to find that a piece procured from the Bottomley Brook bloomary actually yielded 41 per cent of iron, or more by 1·80 per cent. than the ore contains. This must of necessity be an exceptional piece, yet it in all respects resembled that labelled Bottomley No. 1, now upon the table. It is, nevertheless, very evident from even a cursory examination of the slag from any of the old spoil heaps, that only a comparatively small percentage of the metal was actually secured from the stone.

As to the age of these ancient bloomaries it is hazardous to offer an opinion. They undoubtedly existed at the time of the Roman occupation of this island, and evidence is not wanting pointing to a much earlier period. Professor W. Boyd Dawkins, in describing the Wealden iron field,† states that "there is every probability that they (the Wealden iron mines) date far back before the invasion of Cæsar, the discovery of unburnt fragments of pottery, identical in rudeness and coarseness of texture with that termed Keltic, in a cinder heap near Battle would prove that the cinders were at least of the age of the pottery, that is to say, Keltic."

How ever this may be, no doubt can exist that the Romans largely wrought the iron mines of our country, especially those in the Forest of Dean and the Weald of Sussex, where vast accumulations of ancient slags occur, imbedded in which coins of the date of Nero, Vespasian, Trajan, Dioclesian, and Tetricus, together with fragments of Roman pottery and other antiquities, have been found.

"From the period when the extraction of iron from its

* Mr. James Kerr, paper previously quoted from p. 12.

† The History of the Wealden iron field, 1863.

ores was first practised until a few centuries ago at furthest, the art appears to have remained nearly stationary, and it could not have been otherwise so long as the direct process, or that by which metal is obtained in the mallable state by one operation from the ore, was the only one known for this process, as only comparatively small quantities of ore can be successfully treated at a time, and it is so exceedingly simple as not to admit of any considerable improvement."*

The first great step in advance in the development of the iron industry was the discovery of the art of producing cast iron. The time at which this took place is very uncertain. It is, however, on record that a cast iron slab exists in Burwash Church, Sussex, belonging to the 14th century, and according to the antiquarian, Lower, the first cast iron cannons were manufuctured at Buxsted, in Sussex, in 1543 (35th Henry VIII.)

The substitution of pit coal or coke for charcoal in the smelting of iron involved the necessity of increasing the pressure of the blast. This was eventually accomplished, after various methods had been tried, by the adoption of double acting cylinders, which came into use near the close of the last century. This improvement, combined with the substitution of the high blast furnace for the inefficient structure formerly in use, may be regarded as the second great step by which we are conducted up to the improved modern methods of manufacturing iron in operation at the present day.

Bloomaries, nevertheless, continued to linger on for a considerable time, and were not finally abandoned until about the commencement of the present century.

"It was not until 1619 that Lord Dudley obtained a patent for smelting iron ore with pit coal, a mode of operation which was not successfully carried out until many years after that date, and it is known that the Sussex charcoal

* Metallurgy, by John Percy, M.D., F.R.S.

furnaces were not finally blown out till 1790-1800, and those in Staffordshire survived nearly as long,* " whilst at Low Moor, Yorkshire, this ancient mode of smelting iron was directly succeeded by the modern coke blast furnace.

It is difficult to state with certainty the exact structure of these ancient bloomaries from the fact that no remains exist in a sufficiently perfect condition to supply the necessary information, it is, however, highly probable that they were mere temporary erections, circular or oval in shape, about 10 or 12 feet in diameter, the basement being surmounted by a low cupola built of stone and clay. Under the furnace a flue extended to near the centre, used for the purpose of removing the molten metal, and also, possibly, for facilitating the admission of air; the sides were also perforated with holes for the admission of air, which could be opened or closed at will, so as to utilize the current to the greatest advantage which might at the time be blowing in any direction, and to effect this more completely they were generally built upon eminences on the sides of valleys. In emptying and recharging them it was necessary to remove the upper part of the furnace, hence the ruinous condition in which their remains are always found at the present day. Furnaces, very similar in structure to those just described, are still in general use amongst many of the hill tribes of northern India, in Borneo, and Madagascar.

The fuel made use of being charcoal, it was essential to select such situations as afforded the requisite supply of timber for the manufacture of that material.

On the discovery of the art of producing cast iron, and utilizing it for the manufacture of ordnance and numerous other articles, the number of smelting furnaces increased to such an extent, and the consequent consumption of charcoal

* On the remains of some old bloomaries existing in Lancashire, by Mr. James Kerr.

became so heavy as to threaten the total destruction of timber trees in the principal iron producing districts of our country, in consequence of which it was deemed necessary, in A.D. 1586, being the 27th of the reign of Queen Elizabeth, to pass an Act restricting and regulating the use of trees for this purpose, and also for preventing the erection of additional "iron mills" in future.

These coercive measures, combined with the increasing demand for iron, directed attention to the possibility of substituting pit coal for charcoal, which, after many failures and difficulties, became universally adopted, and effected a complete revolution in the iron trade of the country.

The evidence as to the age of the Ruddle Scout mine is of the most meagre description, if, indeed, the little known about it can be considered as coming under this head at all, being confined to the simple knowledge of the existence of subterranean galleries under the hill, but when made, or for what purpose, nothing appears to be known, nor can I ascertain that any documentary records exist to throw light upon the question. It will not, however, be safe to assume a shorter period than two or three centuries—and it may be very much more, as it is difficult to conceive that within a shorter period its history should so completely have vanished from the district where, as a rule, the remembrance of matters of local interest usually linger so long.

In my former paper I mentioned the existence of the remains of three old Bloomaries in the Walsden Valley. Since then several others have been discovered, bringing their number at the present up to seven, and others will in all probability yet be met with. One of these, situated on the Bottomly Brook, has been previously described. Three others are located at Birks Wood, near Walsden church, about 100 yards from each other, upon slightly raised eminences on the easterly slope of the valley, the sites being marked by

accumulations of scoriæ and pieces of burnt sandstone. One is situated on a gentle elevation on the southerly slope of the Ramsden Valley, about 300 yards from the farmhouse. Amongst the slag accumulated here, a piece of iron, described as presenting the appearance of having been used as a die, was discovered a few years ago. One is situated at Banks Wood, near Far Hollingworth, and one between the two waterfalls on the southerly side of the Gorpley Clough.

The whole of these sites are distinguished by heaps of scoriæ, upon which an accumulation of soil covered with herbage has taken place, so as almost to conceal them from observation, and in two cases in Birks Wood large timber trees have found a congenial soil over the mounds of slag, all tending to indicate a remote period for the active operations of the Bloomaries of this locality.

In conclusion, I desire to express my indebtedness to Mr. Abraham Stansfield, of Todmorden, for kindly drawing my attention to the existence of the old ironstone mine, to Mr. Robert Law, of Walsden, who has rendered me valuable assistance and information respecting the ancient Bloomaries of the district, and Mr. Peter Spence for analysing the iron ore and scoriæ.

SPECIMENS EXHIBITED.

Several pieces of ironstone from old mine.
Slag from several of the Walsden Bloomaries.
Piece of burnt sandstone from Birks Wood, Walsden.
Burnt shale from Ruddle Scout.
Roasted ore from Ruddle Scout.

Mr. PETER SPENCE said: They analysed two specimens which Mr. Aitken gave them—one of the ore, which is an ordinary clay ironstone one, exactly similar to those which are used chiefly at the Low Moor iron works; and it seemed if it had been got in the usual way. It is deposited in the

shale in a sort of strata, but being in detached pieces they bring up the ironstone with a good deal of the shale sticking to it, but the shales, having that laminated structure, are easily affected by the atmosphere, and fall away, leaving the ironstone clean, the pieces being in some cases as large as a horse's head, in others not bigger than a penny piece. That is the kind of ironstone from which, at the Low Moor Iron Works, for many years, they had produced almost the best iron in the country. It had a very high character for boiler plate for a long period. I know it very well, for 25 years ago I could not get a shale to answer my alum manufacture, in this district. With the knowledge I then had of the operation, I went to the Low Moor Iron Works and got the shale there, as it had fallen off, and was clean from those ironstone lumps, which we did not want. We calcined it, brought it to Manchester, and made alum from it. After two or three years we found better material near at hand.

Mr. DICKINSON: It is very satisfactory to find that Mr. Aitken has discovered the source of the ores by which these bloomaries were supplied. It is well the Society has not been left under the impression that iron was obtained from iron pyrites as produced at the former meeting. There is one point I thought Mr. Spence might have touched upon, being a chemist—that is, the per centage of iron left in the old scoriæ. The scoriæ produced are not what we would call pure furnace slag. This slag which is lying on the table is like what would flow off from the refining process, rather than that from the smelting process, and being a protoxide of iron, instead of a carbonate of the protoxide in which it exists in the ore, it is necessarily much richer, although combined with the silica which originally existed in the ore and in the flux. There are open works within a few miles of this district, where, according to repute in the neighbourhood, ironstone has been worked in former times, all open cast—

not by mining as Mr. Aitken has described. The paper is a very interesting one, and throws some light upon the history of that district.

Mr. BETLEY (Wigan): The secret of the large per centage of iron in the slag is to be found in the fact that the users of these ancient bloomaries were not aware of the use of lime as a flux in smelting. In our ordinary blast furnaces, the ore and coke are now applied in connection with limestone, limestone combining with the silica of the ore and setting free the iron. The silica, if not saturated, will combine with iron and take up a considerable quantity, thus rendering the slag highly ferruginous. With regard to the yield (something like 40 per cent.) I may say that is not at all exceptional, the yield given by Dr. Percy, in his book, of some slags from ancient bloomaries being over 50 per cent. of protoxide of iron, which is easy calculable into nearly 40 per cent. of iron; and a sample which I myself found some years ago of slag from an ancient bloomary, a little north of Middleton in Teesdale, yielded me almost precisely the same amount. I forget the exact figures, but I think it was 40 per cent., of iron.

Mr. SPENCE said that some slags from bloomaries contained as much as 60 per cent.

Mr. PLANT: It is not very likely in the present state of trade, and of the iron trade especially, that this ancient mine will be re-opened for commercial purposes, although the deposit exists perhaps as good, if it were further examined, as it did in the times when it was worked. The chief interest of the subject is in the geological definition of its exact site in the coal measures. I was not quite certain whether I understood Mr. Aitken to say that these nodular bands lay in the lower coal measures, and whether he has determined in his own mind that the age which he can find for the old workings would be three or four

centuries ago—before the time of Shakspeare. If that is the calculation arrived at, it is very satisfactory, because it does not leave the matter open for further conjecture as to pre-historic, or Celtic, or even Anglo Saxon working. But the working of iron, of a very primitive character, was a well established industry in Great Britain from Anglo-Saxon records; and unless there is direct proof of these mines having been worked in the time of Henry VIII., there is no reason why he did not extend the age a little longer and carry it back to Anglo-Saxon times. They used to extract iron ores in those days, and smelt them in a very primitive fashion sufficient for the day. I should like to be quite certain from Mr. Aitken's statements whether it is the lower coal measures in which the bands occur.

Professor BOYD DAWKINS: I should like to make a remark upon the ancient mode of working iron in this country. The large series of observations made by Mr. Lower, in Sussex and Kent, and by myself and other members of the Geological Survey, have tended in this conclusion, so far as relates to the ancient mode of working iron ores. There are large tracts of country covered by wood in the Weald of Sussex and Kent, small-poxed, so to speak, with cavities, and when these are examined, they are found to represent filled up shafts. It has been found in every case that these shafts have been made in the search for a series of nodular iron-stone precisely of the same character as those which Mr. Aitken has put before us. The mode in which they were worked was thus. The miners sank a vertical shaft, very seldom more than 40ft. deep, and when they got down to the iron ore they removed all within reach. Apparently they did not know how to support the roof, nor were they accustomed to drive passages. Having got out as much of the iron ore as they could, they sank another shaft, and proceeded to fill up the previous one with the *debris*, and as a result of that

operation, repeated over and over again, considerable districts are covered with these small depressions, which represent the filled up shafts of old ironstone mines. These pits are not confined to this country. They are found also in France and in Belgium, and it seems to me they represent the most archaic, the oldest, form of iron mining known. Now, with regard to the age of these iron mines, we know as a matter of fact that the iron of Sussex and Kent was one of the most important sources from which Great Britain was supplied down to as late a time as the reign of Henry VIII., and there are not known in any part of that district any large horizontal workings; there are no passages extending far away from the old shafts. It seems to me, therefore, very probable indeed that this mode of working is the very oldest form of iron-mining at present known. It was also the mode in which the Neolithic peoples mined flint in this country. The more complicated and elaborate workings, which Mr. Aitken has so well put before us this afternoon, probably do not date more than perhaps three, or at most four, perhaps not so much as four, centuries from the present time. As people learned to use timber in supporting the roofs of mines the old mode of working went out of fashion, and I believe that it could very well be proved that it went out of fashion somewhere about the time of the reign of Elizabeth. But that is a question I am sure Mr. Dickinson, or some other gentlemen here, will be able to give much better information of than I can. I feel very much obliged to Mr. Aitken for his interesting paper.

Mr. DICKINSON said that many of the old pits in the neighbourhood of the sub-Wealden bore-hole had not, to his mind, been made by sinking from the surface, but they were what was known as bell pits—that was to say, by working underground for a certain distance from the shaft, a sufficient excavation was made to cause the surface to fall in. That

was nothing new: it was a system practised until recently in working iron-stone where it was very shallow.

Professor DAWKINS said the evidence was to his mind conclusive that the old mines in Sussex had been worked from above.

Mr. AITKEN, in replying, said that the bed of shale lay 14 feet below the Arley mine, and taking that as the basis of the middle coal measures the iron stone deposit would lie in the uppermost part of the lower coal measures. As to its age he quite agreed with Professor Dawkins; he thought that the old mine which he had described, although extending back for a considerable period, would not rank, in antiquity, with those so well described in a paper by Professor Dawkins published some time ago (and to which he had referred in the paper read that day), because there they were surface workings, known to have existed at a very remote period. Here, the ironstone occupied a different position to that in the Weald. It outcropped on the face of the steep escarpment, and would be visible to those who were seeking for it, and the character of the shale was such as enabled the iron to be extracted with facility, and at much less cost than in sinking from the surface.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL XV. SESSION 1879-80.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 27th day of January, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

E. W. BINNEY, Esq., F.R.S., &c., Vice-President,

in the Chair.

Mr. William Fairclough, Land and Mineral Surveyor, Leigh, Lancashire; Mr. William Jackson, Bower Colliery, Hollinwood, near Manchester; Mr. Mark Stirrup, F.G.S., Heywood Street, Moss Side, Manchester; and Mr. William E. Teale, Fern Bank. Worsley, were elected ordinary members; and Mr. Christopher James Schofield, Whalley Villa, Whalley Range, near Manchester, (having compounded his subscription) a life member of the Society.

THE METHOD ADOPTED IN SINKING THROUGH QUICKSAND AT THE BAMFURLONG COLLIERIES, WIGAN.

BY WALTER TOPPING, M.E.

The following notes and observations apply rather to Mining than to Geology, but to those members who are closely identified with the coal industry, they may be of

interest, and generally it may be urged that, in addition to the mere *knowledge* that rich treasures lie under our feet, it is of very great importance that we should *all* have some idea of the practical difficulties which lie betwixt us and these treasures.

I propose by the accompanying plans to shorten as much as possible the description of the work. I must at the outset call attention to the relative positions of the shafts as well as to the machinery, boilers, buildings, and canal; also the necessity of *limiting* the superficial area of disturbance as be understood more particularly by reference to No. 1 Plan.

No. 1 Pit was sunk about forty-five years ago, by Mr. Adam Platt, to the Ince four and seven feet mines who, I believe, was the first to attempt to work the valuable mines under the Bamfurlong Hall Estate.

This pit was five feet two inches in diameter, and had to serve for pumping, winding, and ventilating purposes. A few pillars in the Ince four feet mine were gotten, and in consequence the sand broke in, and the pit was abandoned. When Messrs. Cross, Tetley, & Co., (Limited) obtained a lease in 1867, No. 2 shaft after much difficulty was sunk by means of wooden curbs, and a shaft of twelve feet diameter secured, which was then sunk to the Pemberton 4 feet mine; No. 1 shaft was also sunk of the same size, *from* the Ince 4 feet mine to this seam.

The coal-field having been proved by these shafts, the Company at length decided to widen No. 1 shaft from the surface, and to sink two others to the Wigan Series of mines. In May, 1873, No. 3 shaft was commenced. Staging was erected about 15 feet high, and a light headgear with pullies put thereon. At the depth of 4 feet the sand was reached. Cast-iron curbs in segments making 20 feet outside diameter, were then put together as high as the stage would admit.

These segments were 3 feet 8 in. long, 2 feet high, with inside flanges 5 in. broad, and two 3 in. and 1 in. thick strengthening ribs, these running longitudinally and vertically. Each *third* ring in height had a flange 10 in. broad. The leading or cutting ring was 3 feet in height with 12 in. flanges and metal 1¼ in. thick. This ring was 2 inches larger externally than the others, the idea being, I suppose, that the upper rings would thereby be relieved of some pressure. Wood sheathing ¾ in. thick was put between each joint, and the segments were tightly screwed together by ⅞in. bolts. Planks were then laid across from the broad flanges, and dry bricks placed (breaking the joints in the usual way), from the recesses formed by the ribs until the requisite weight to sink the curb was obtained.

Sinking was next commenced, and only suspended to add more castings, until the curb was driven 6 or 7 inches into the marl. The Upper sand presented little difficulty, being, when dry, much of the same character as that ordinarily used for building purposes, and not under much pressure. The Lower sand, however, is as fine as "wheaten flour," and when rubbed betwixt the thumb and finger, in water, is scarcely perceptible to the touch.

A wooden ring, 3 in. thick, was laid some distance in the marl, which was sheared back in coming upwards, and 4½ in. walling brought up the sides flush with the cutters.

The marl was then sunk through, and No. 2 tubbing, of about 18 feet diameter put in. Weight was introduced as in No. 1 tubbing, until the space for the hoppets to pass through was reduced to 8 feet by 4 feet.—See Plan No. 2.

The workmen had barely head-room to work beneath the weight. Segments were added as required. The water was raised by Cameron's steam pumps, 10-inch steam cylinders, and with 7-inch rams. They were placed within the curb

17 or 18 feet from the bottom, and at times did good service; but owing to the delay involved in cleaning and washing out the clacks, and the uncertainty of re-starting, day after day was lost. Thin flaps of indiarubber were placed on the valves, and by this means the pumps acted more effectually than when working with brass to brass upon the facing, but they were frequently cut through, and had to be renewed. The curb became stationary, and for a fortnight no headway was made in the boiling sand, although it was weighted with 120,000 bricks. Six hydraulic jacks were then obtained, of an effective power of 240 tons. These were placed between the upper and lower curbs, with no other result than that both curbs were very seriously damaged, the lower becoming almost unfit to run further. The work came to a standstill, and in November of that year (1873) the writer was asked to take charge.

The No. 1 tubbing was at once strengthened with stretchers of pitch pine. The state of No. 2 could not be seen at this time, owing to the bricks, except where the engine was situated. Two open lifts of 4 and 8 inches diameter were at once put in. Operations were again commenced. Sand was pumped in quantities requiring a large staff of men to keep the troughs and water-ways clear. We frequently found, when within about a foot from the top of the leaders, that it became impossible to go deeper; the water and sand breaking in, and rising 10 or 12 feet in a few seconds. With this outflow from time to time, and the pit no deeper, the state of the surface may be imagined. The ground began to crack, the soil and marl having no support; the curbs had an ever-extending circumference of broken surface, and consequently additional weight to resist. Bolts snapped like glass, castings split from top to bottom, and the sand boiled over the back of the inner curb.

The conclusion had been previously come to, that the

curbs were in rigid contact, and also that a fracture, on the rise side of the pit, had taken place in the leader. Not only did the surface become depressed more upon this side (fortunately for us), but the first symptoms of an out-burst came from this point. There was now no alternative but to introduce No. 3 curb, though we had made great sacrifices to secure, if possible, a shaft of not less than 16 feet diameter, which we were anxious to obtain. The bricks were removed, the No. 2 curb strengthened, and, as plan No. 2 will show, a 3 in. flange curb was run, and successfully landed in the marl, December 3rd, 1873. The space between the two curbs was well and constantly packed with straw, as we feared that the upper and lower sands had become connected. The section (plan 2) shows the method of sinking from this point, also the wedging ring (W.) laid in the rock upon which the water tubbing is bedded. Strict care was taken to find a suitable site for the ring, as it was necessary that the rock should be free from joints. The bed was carefully levelled, no powder being permitted to be used. Dry ends of spruce were used as blocking, (X) care being taken to collect the water from the sides in canvas bags, in order to prevent the blocks swelling before the operation of wedging had been completed. Dry pitch pine wedges were used, and when these would not face the blocking, iron wedges were inserted until the ring was secure. The ring (W) was hollow, 14 feet diameter, 4½ in. high, and 12 in. broad. The water tubbing had 3 in. (*outside*) flanges, and over-lapped 1 in. at the back, on two of its edges, to prevent the wedges and sheathing being driven through. The first round of tubbing was laid on the ring, with ½ in. sheathing between the joints. Fine riddled slag, from the blast furnaces of the Wigan Coal & Iron Co., was flushed round the back. This soon became as hard as the rock. The full height of water-tubbing was erected in the

usual way, when wedging was commenced from the bottom upwards. This was repeated three times. In this way the water was effectually made out; but not until it was considered that the ground had quite settled, was the water allowed to flow from the discharge pipe (B). We gradually added short lengths of 2 in. pipes up the shaft, constituting a safety valve, until the maximum pressure was thrown upon the tubbing. In consequence of the tubbing having become so weakened by fracture from the weight imposed upon it, and having assumed various shapes from time to time, we were never clear of difficulty and anxiety until the pit was made good; the removal of the pitch pine struts being attended with considerable risk.

Plan 3 shows the displacement at the several depths, &c.; and Plan 4 gives the diameters and depths of each set of tubbing.

The walling was completed February 15th, 1874.

The pit was then sunk to the Ince 4 ft. mine and a communication made with No. 1 shaft for ventilation.

We then turned our attention to No. 1 shaft. I will first describe what we found in the old shaft; or rather the means taken to sink it, as far as I could ascertain. Plan 5 gives the section.

At the outset a wooden curb A formed of 3 in. pitch pine planks nailed to oak rings 4½ in. square, was made of half the required height, and was shod with ¾ in. wrought iron plating. This having been run down level with the surface, the other half was joined to it. It was expected to have got through both sands with this, but Plan 6 gives an idea of its incapacity to sustain the pressure. What had been a circle of 12 feet, was elongated to upwards of 14 feet 6 in.

A wrought iron curb B of boiler plates, leaving a margin to allow of its insertion was put in, but it,

also, collapsed. Inside this, four cast iron cylinders C, 6 feet 11 in. outside diameter, 7 feet 7 in high, and 1 in. thick, with inside flanges 5½ in., were, after spreading a layer of paint and oakum, bolted together. The lowest was without flange and bevelled, and was ultimately cracked.

Another cast-iron cylinder D, 5 feet 10 in. in diameter, 4 feet 6 in. in height, with 4 in. flanges, was inserted inside the "C" cylinders, and forced into the marl. This, bricked flush with the flanges, formed the sides of the shaft. It is probable that "C" cylinder had kept back the sand, but owing to the absence of a flange at the bottom, it was unable to resist the additional external weight, and, when the marl was removed from within, became damaged. These two sets and the wrought-iron ring would be at once blocked up; small bricks, well set in mortar, being found betwixt them, Below this, six oak rings, 5 in. deep, were laid on each other, and a wrought-iron ring in 5 segments, bolted inside, but *not* diminishing the diameter. Thus Mr. Platt secured his shaft.

I will now describe the means which were adopted in enlarging this shaft.

The first curb was of the same pattern as No. 3 save that the cutting flanges were less. It was built as high as the shear legs would allow of, and run down to the surface, and the remaining height then bolted on. Four long poles, 63 feet in height, lashed together at the top, from which a pulley was suspended, formed the headgear. These rested on long balks, the ends of which were well supported, and the weight thereby distributed to a distance from the shaft. Upon the top of the tubbing balks upwards of 50 feet in length was placed, with planks laid crosswise to constitute the platform. Small wagons containing scrap iron were ranged round the extremities, and the remaining space

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The first curb was of the same pattern as No. 3 save that the cutting flanges were less. It was built as high as the shear legs would allow of, and run down to the surface, and the remaining height then bolted on. Four long poles, 63 feet in height, lashed together at the top, from which a pulley was suspended, formed the headgear. These rested on long balks, the ends of which were well supported, and the weight thereby distributed to a distance from the shaft. Upon the top of the tubbing balks upwards of 50 feet in length was placed, with planks laid crosswise to constitute the platform. Small wagons containing scrap iron were ranged round the extremities, and the remaining space

was covered with bricks and pig iron. The weights were transferred from side to side as necessity demanded, to keep the curb erect. The curb went rapidly home, much advantage being gained by the vibration occasioned by the landing of the hoppets, &c. When about entering the marl it was found the flange of the cutters was in contact with the wooden curb. Our task was to be no easy one, as the centre of the small shaft was not the original centre of the wood curbs which had been pushed down obliquely.—See Plans 6 and 7.

No. 2 curb, 17 feet diameter, was put in; but before the third ring had been completed it sank so much out of level, and the outer curb pressed so against it, that it became firmly jammed. It was abandoned and left, and blocked with oak where the spaces would admit. Two stiffening rings, 7 in. high and 5 in. broad, well bracketed, were placed 1 foot and 2 feet respectively from it, and blocked solid.

These prevented further collapse. Short railway metals (40 lbs. to the yard) were introduced from segment to segment, and wedged firmly in the pockets, and kept the sides from bulging. These rails were chained to the curb, lest they should become loosened and fall under the leader. Another set of curbs, 14 feet 6 in. diameter, was now attempted to be commenced; but the segments, before two could be bolted together, sank, until at last we suspended them from half-a-dozen pairs of blocks hung from the outer curb; and when we had secured three rings, we let them go, and afterwards built them up to the full distance they had to run. Hay and straw were tightly pressed behind. We were now prepared to sink. Not much weight was required, as the curb could not be sunk more rapidly than the obstructions could be removed. The work was tedious, both on account of the little room which we had to work in, and the time

occupied in cutting, with long diamond-pointed chisels, the iron boiler plate which projected under our sinking curb. Once or twice there seemed no hope of success. The ground broke near the canal, and water found its way into the pits. Near to the boilers it was subsiding also, and it was feared that the chimney might fall. We had taken the precaution to shorten it by 12 yards. We could have no other foundation than the bare surface, and previously we had been under the necessity to saw out upwards of 3 in. from one side of the stack to bring it erect. The great point was to remove no more sand than that due to the area of the pit, or failure was ensured. To have disturbed the pillars of the engines, &c., the whole operations of the colliery would have been suspended. Our output equalled nearly 300 tons per day from No. 2 pit, and realized the highest prices ever obtained.

Upon the slightest symptom of outburst small bundles of straw, well bound, were thrown into the pit, and short planks put over them, upon which the men stood, and counteracted (the outer pressure being thereby relieved,) in some degree the pressure by their weight. The water only drained through, and the sand was stopped. We had no need of pumps. The water was turned down the tube, and afterwards pumped into No. 2 pit sump, and wound to the surface in tanks. Provision had been made for ventilation by the drift from No. 3 pit, should we be compelled to bolt the lid upon the "air tube" (Plan 5), but, except upon one occasion, the necessity did not arise. Marl was reached June 12th, 1874, after we had been engaged upwards of two months in passing through the lower sand. The method described in No. 3 pit was adopted, and 37 feet of water tubbing inserted before we could commence walling.

No. 4 Pit.—This pit was commenced with tubbing 27 feet diameter, which was in every respect much stronger than any we had hitherto used. The flanges were 6 in. broad, the

metal thicker, and ribs introduced where possible with the addition of a strong lip overlapping the joint at the back, similar to that of the water tubbing.

The cutters were not different to the ordinary segments, except that they were without the flange. The No. 3 cutters, from their shape and height, had a tendency to wedge themselves outwards. The strength of the bolts was increased by one-eighth of an inch, and six-sided nuts were used, these being more readily accessible. The sheathing did not exceed half-an-inch, and the curbs had less disposition to bulge. The earth down to the sand was taken out 3 feet in excess of the diameter, and the space was well filled with light brushwood and straw. Twenty-five feet in height of tubbing was erected, and four logs, 56 feet long, placed transversely upon it, carried the 10 in. cylinder engines and four windlasses. These were worked by four men, with one spare man, and two banksmen to each windlass. Numerous assistants kept the water-ways clear, and conveyed the dry and solid sand away to a considerable distance from the shaft. Two sinkers were specially employed at each pump foot, the pumps taking the lead about 8 or 10 in. The greater proportion of the sand was by this means sent out dry. One man was engaged solely tightening the bolts.

The whole of the three different sets of tubbing were delivered before sinking operations commenced, and these were used for weighting by placing them inside (bolted together), close to the circumference. This length being run down, the remaining 15 feet were added, and the platform and windlasses again restored. In less than six days we had run through the upper sand—viz., 9 yards. When the curb was sufficiently embedded in the marl, piles 8 in. broad, 3 to 4 feet long, were driven laterally under the cutters, to prevent, if possible, No. 1 curb from going lower when the second

sand was disturbed. The marl was bricked up from a wooden ring, as described in No. 3 pit. Another length of tubbing was put inside this brickwork, and suspended from No. 1 curb. The main object was to keep back side-pressure, so that the next course of tubbing might have to compete only with its own pressure. From the marl a borehole was put down 9 yards. Finding layers of white sand and loam, in lieu of quicksand, it was thought to be probable that the lower sand had been washed out; but we were doomed to disappointment. We were then 20 yards deep (the total depth of the other pits), with the lower sand beneath us. Within a foot of it, we inserted 35 feet of tubbing 24 feet diameter; and suspended within this, from sets of blocks hung five feet apart, two rings of segments, making 10 feet vertically of 19 feet diameter, for immediate readiness, should No. 2 curb not accomplish its object. Between the first and second curbs straw and litter were well stemmed down. No. 1 curb was strengthened with timbers and metals (70 lbs. to the yard).

A double-acting Cameron pump, with separate deliveries, but connected with the rising main by two taps, so that one engine could be overhauled and washed out whilst the other was in motion, greatly added to our success. The sand in the ascension pipe was kept moving, and in solution, and, consequently, could not deposit itself on the clacks.

The clacks had more lift, and the valves were of india-rubber one inch thick. This engine could not only pump sand of great consistency, but would pump pieces of coal as large as two walnuts. One of these pumps was placed 8 feet from the bottom, and the other 11 feet higher up, on the opposite side, both being within No. 2 curb. Another pair of Cameron's pumps were ready on the surface if required. The hauling engines were those used

at No. 1 pit, the rope being conducted (130 yards) from thence on regulating pullies. Galvanised tubes, 11 in. diameter, formed the speaking-trumpet, and ran from the bottom of the shaft into the engine-house. By this means the engineer could, without difficulty, hear all that was going on.

Weight was now added, as heretofore described, by placing bricks over the engines as high as the stretchers across No. 1 curb would admit. Sinking was commenced, and in ten days the lower sand was run through. The pumps gave every satisfaction. No water tubbing was required, the brickwork being laid in cement. The total weight of tubbing was 225 tons 5 cwt. 1 qr. 1 lb.

The pit, when secured, was 21 feet in diameter at the surface, contracted to 16 feet 4 in., its smallest diameter, at a depth of 40 yards.

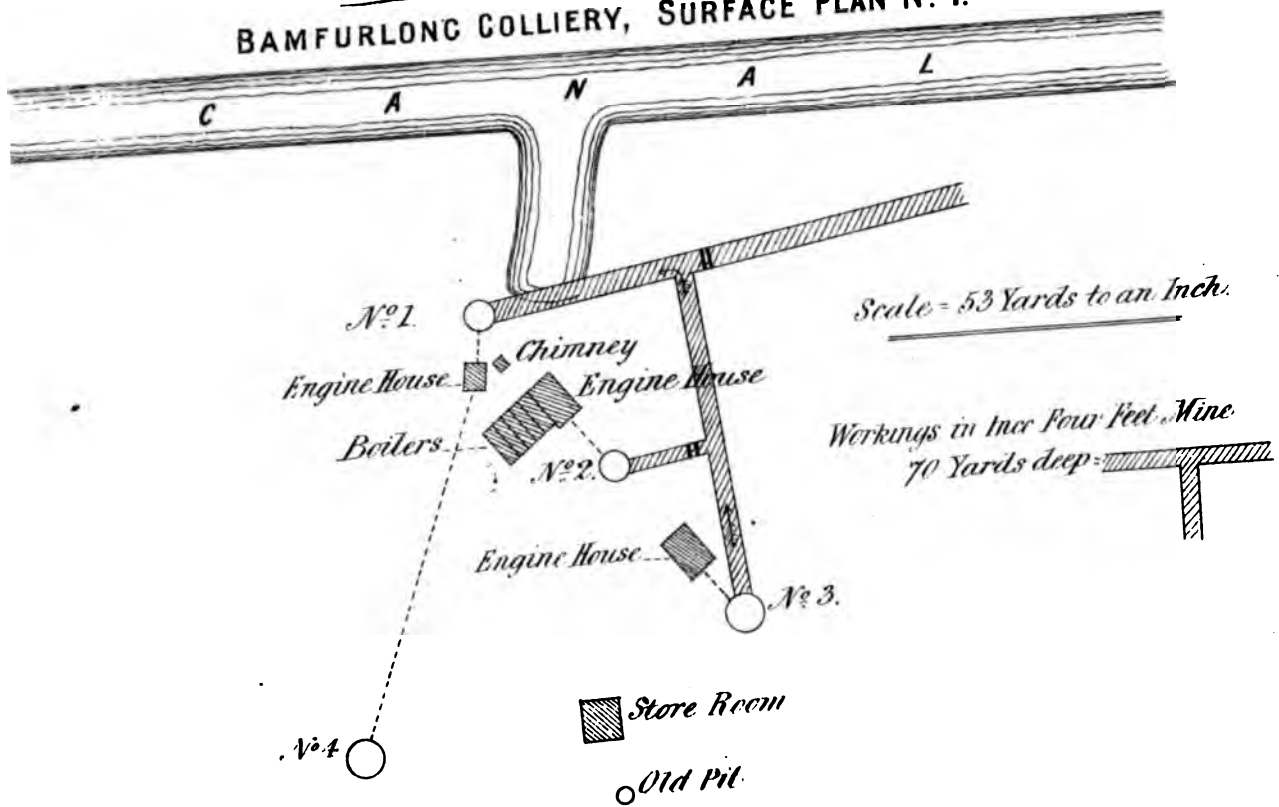
The Discussion was adjourned until the paper is in the hands of the Members.

NOTES ON THE MORE RECENT DISCOVERIES IN THE CRESSWELL CAVES.

BY THE REV. J. M. MELLO, M.A., F.G.S.

It will perhaps be remembered that some time age a sketch of the earlier discoveries made at Cresswell was read before this Society. The object of the present communication is to give a brief account of the concluding portion of the work of exploration. In doing this I must in the first place sum up as shortly as possible the general results gathered from the researches in the Robin Hood and Church Hole Caves as by so doing we shall be able to understand clearly the bearing of the additional facts obtained from the Cave known as Mother Grundy's Parlour.

BAMFURLONG COLLIERY, SURFACE PLAN No. I.

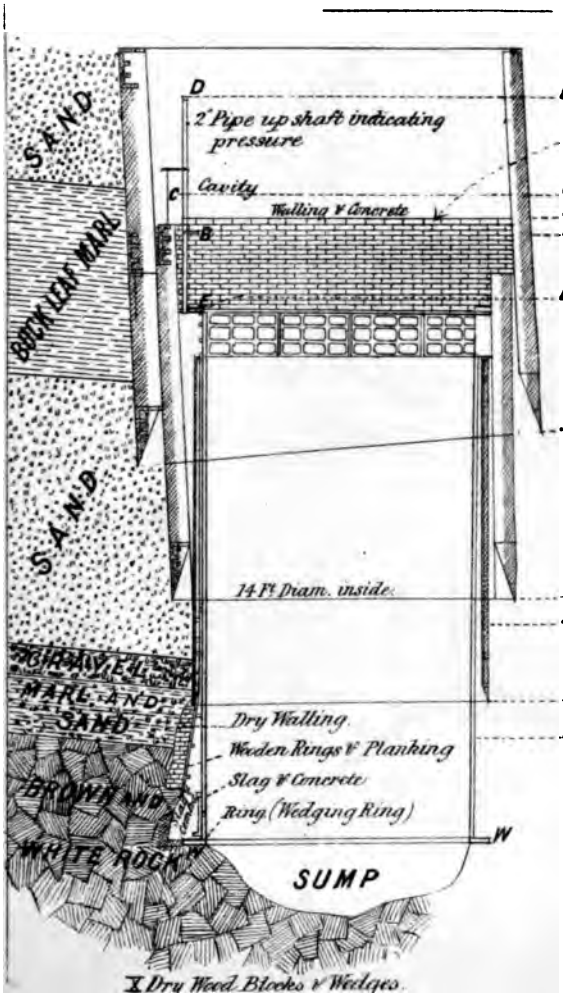


PLAN 2.

Nº 3. PIT.

Sunk to Wigan Mines. 400 Yards.
All the water tubbed back.

Scale. 10 Feet to 1 Inch.

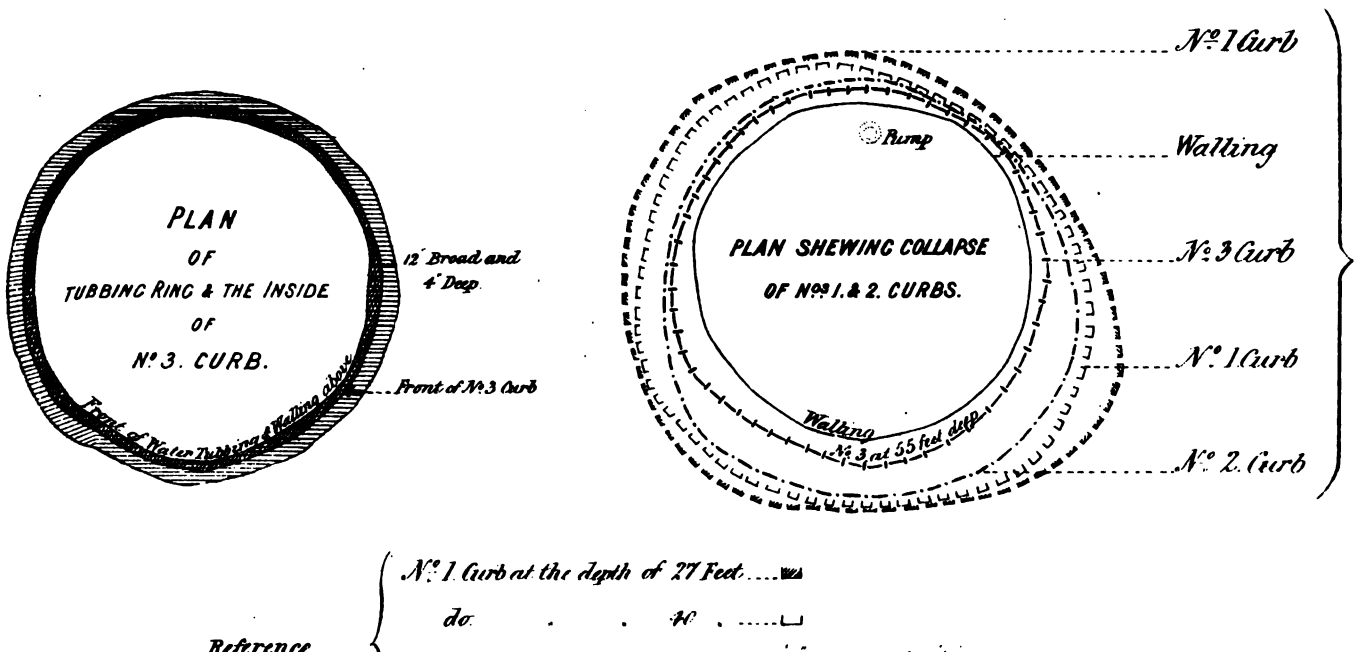


Trans. Man. Geo. Soc. Part XIII. Vol. XV.

PLAN 3.

Shewing Collapse at various depths.

Scale 8 Feet to 1 Inch.

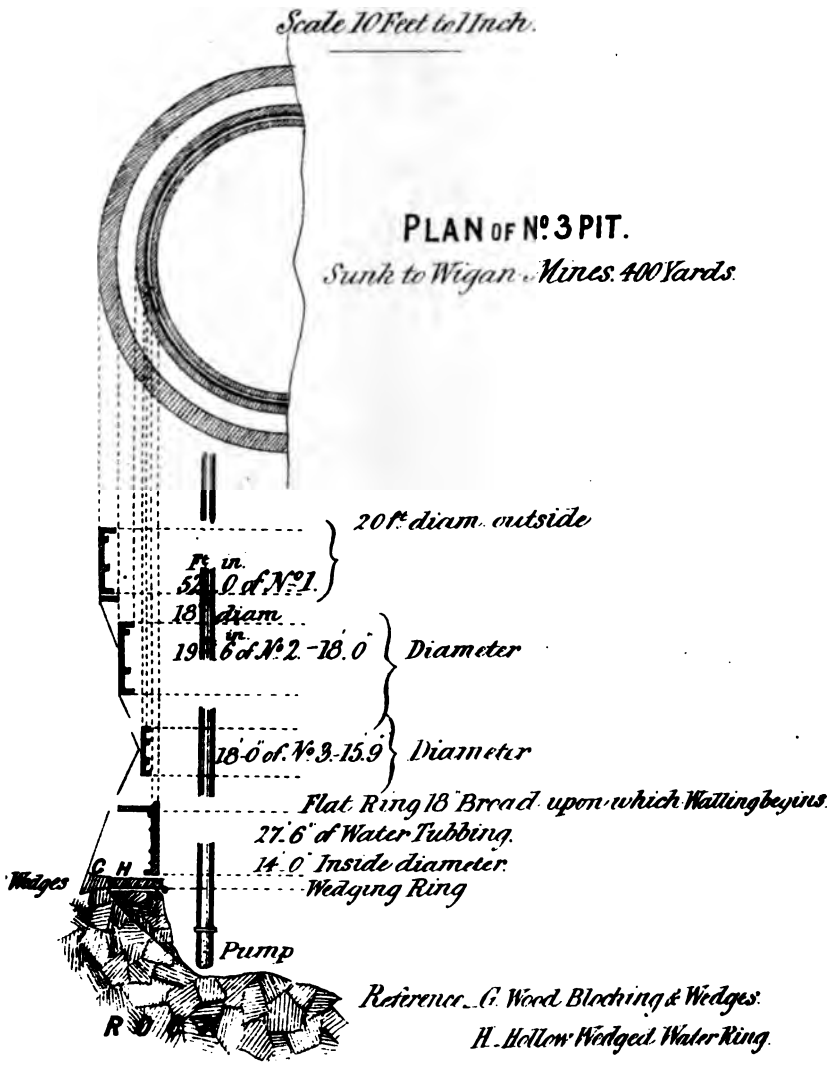


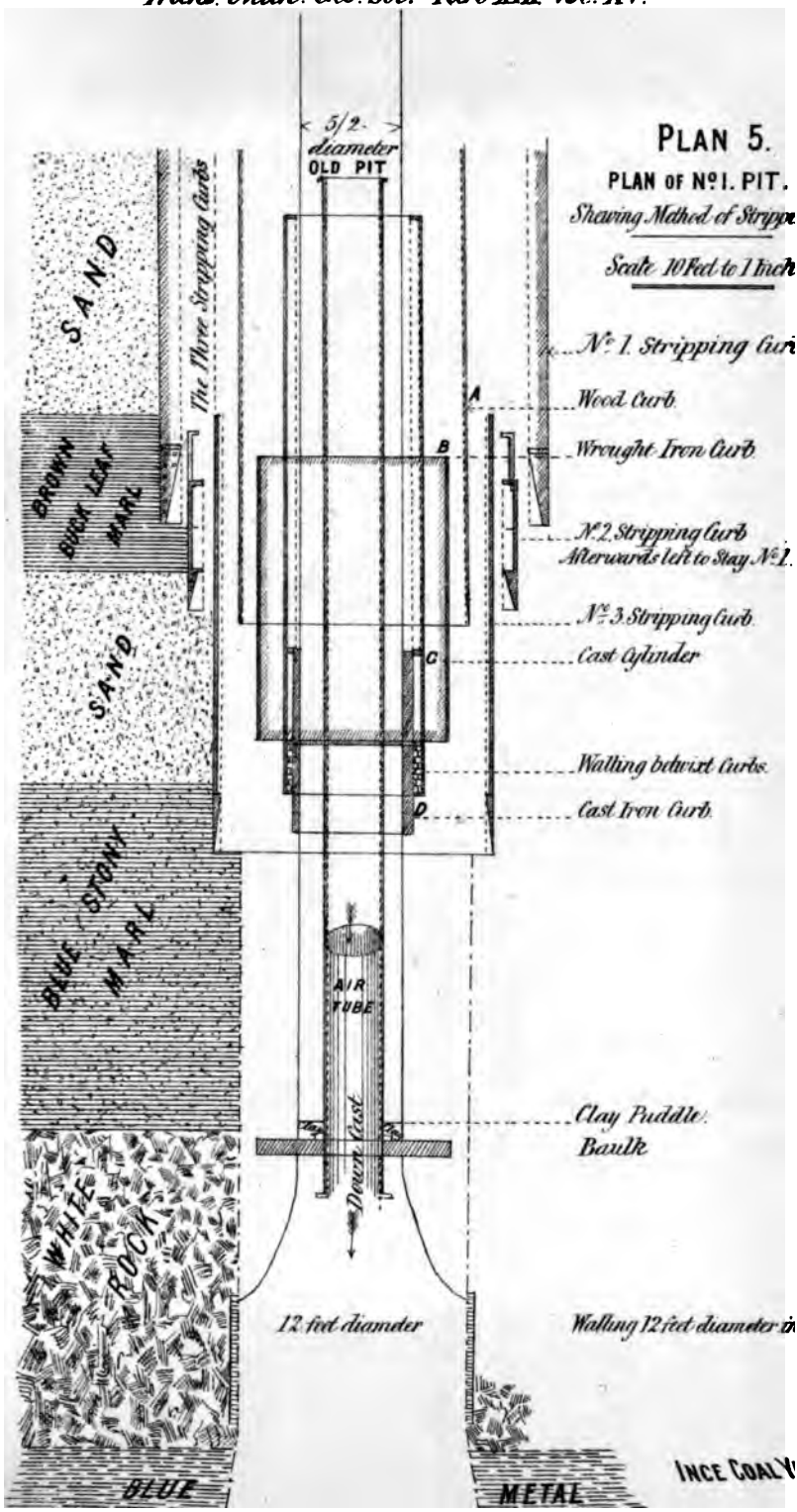
Reference

No 1 Curb at the depth of 27 Feet....
do . . . . .

PLAN 4.

Shewing the different Diameters of Curbs & their depths &c.

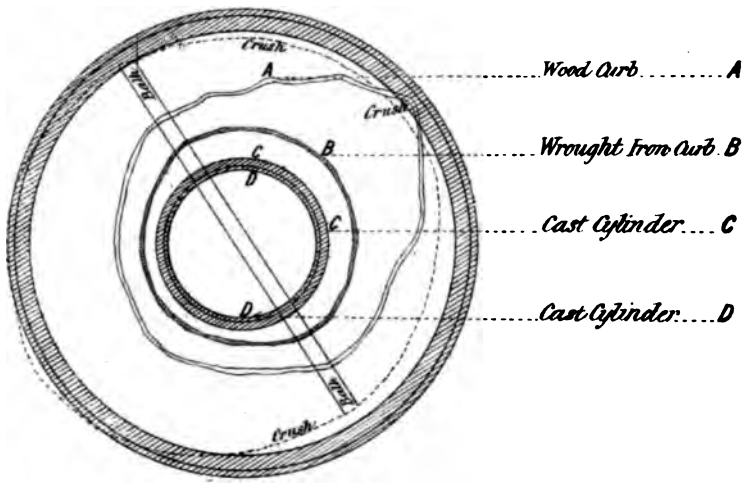

Scale 10 Feet to 1 Inch.
PLAN OF Nº 3 PIT.
Sunk to Wigan Mines. 400 Yards.
20 ft. diam. outside
Ft. in.
52 0 of Nº 1.
18 diam.
19 6 of Nº 2. - 18. 0
Diameter
18-0 of Nº 3. - 15. 9
Diameter
Flat Ring 18 Broad upon which Walling begins.
27. 6 of Water Tubbing.
14. 0 Inside diameter.
Wedging Ring
Wedges
C H
Pump
R
Reference. G. Wood Blocking & Wedges.
H. Hollow Wedged Water Ring.
above G.H. filled with Slag & Cement


PLAN 5.
PLAN OF Nº I. PIT.
Shewing Method of Stripp
Scale 10 Feet to 1 Inch
5/2 diameter OLD PIT
The Three Stripping Curbs
SAND
BROWN BUCK LEAR MARL
SAND
BLUE STONY MARL
WHITE ROCK
BLUE
Nº 1. Stripping Curb
Wood Curb
Wrought Iron Curb
Nº 2. Stripping Curb Afterwards left to Stay Nº 1.
Nº 3. Stripping Curb
Cast Cylinder
Walling betwixt Curbs
Cast Iron Curb
AIR TUBE
Down Cast
Clay Puddle
Baulk
12 feet diameter
Walling 12 feet diameter in
METAL
INCE COAL

PLAN 6.

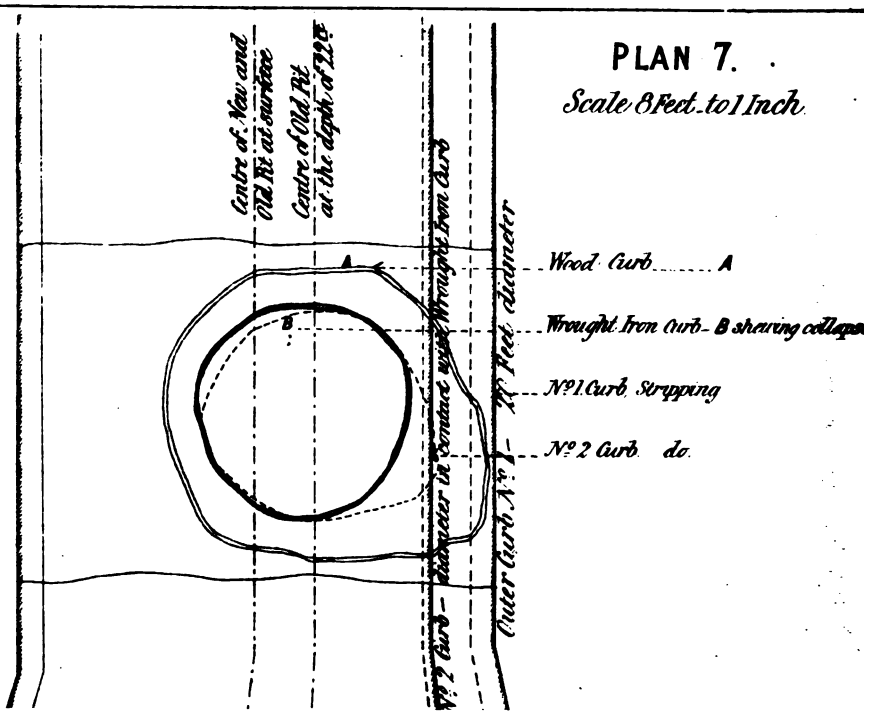
Little Pit or No. 1 Shaft sunk first to Ince Mines 5/2 diameter & subsequently stripped & sunk to Pemb Mines 220 Yards 13 Feet Diameter.

Scale 8 feet to 1 Inch.



PLAN 7.

Scale 8 Feet to 1 Inch.


Centre of New and Old Pit at surface
Centre of Old Pit at the depth of 220
A
B
Wood Curb ..... A
Wrought Iron Curb - B shearing collapse
No 1 Curb Stripping
No 2 Curb do.
Outer Curb No 1 - 17 Feet diameter

The Pin Hole Cave, although numerous mammalian remains of great interest were found in it, need not now be particularly referred to, as the more important results have been derived from the larger caves the Robin Hood and the Church Hole. Both of these contained a well defined sequence of beds which may be correlated, there being a close similarity between the deposits found in them, and which were in all probability synchronous. In general terms these beds may be described in descending order as follows:—

1. Surface soil a few inches thick.
2. Stalagmitic breccia varying in thickness from a mere film to three feet.
3. Cave earth from 3 ft. to 4 ft.
4. Red sand and clay about 3 ft.
5. Light sand, forming the original decomposed rocky floor of the caves.

The thicknesses and also to some extent the mineral composition of these several beds varied in different parts of the caves, the breccia for instance was in places entirely absent and was represented by an increased thickness of the cave earth. The stalagmite which was in one part of a cave present in large quantities cementing the fallen blocks of limestone into a dense mass, in another part was a mere decomposed film. Still throughout these two caves the general character of the beds was tolerably uniform. In these beds, with the exception of the uppermost layer of surface soil, numerous remains of the Pleistocene mammalia were found in conjunction with the implements of Palæolithic man.

The list of animals represented in these caves is both a long and a remarkable one, and if we include the Pinhole Cave, besides man we have the remains of no fewer than 19 species of mammalia. These are:—

1. **Machairodus latidens.**
2. **Felis spelæa** ..... **Lion.**
3. **Felis catus** ..... **Wild Cat.**
4. **Felis pardus** ..... **Leopard.**
5. **Mustela putorius** ..... **Polecat.**
6. **Hyæna crocuta** ..... **Spotted Hyæna.**
7. **Canis vulpes** ..... **Fox.**
8. **Canis lagopus**..... **Arctic Fox.**
9. **Canis lupus**..... **Wolf.**
10. **Gulo luscus**..... **Glutton.**
11. **Ursus arctos** ..... **Brown Bear.**
12. **Ursus ferox** ..... **Grizzly Bear.**
13. **Cervus tarandus**..... **Reindeer.**
14. **Cervus megaceros** ..... **Irish Elk.**
15. Bison priscus ..... Bison.
16. Equus caballus ..... Horse.
17. Rhinoceros tichorinus .. Woolly Rhinoceros.
18. Elephas primigenius .... Mammoth.
19. Lepus timidus ..... Hare.

An examination of the bones and teeth of these various animals shows that some species were far more abundant than others, and also that slight changes in the fauna of the district probably took place during the time represented by the accumulated deposits in the caves; and it is also probable that not only in this particular district, but over a very wide area in this country, if not in other parts of the continent of which we then formed part, the wild fauna was everywhere represented by certain predominant species. Professor Dawkins has pointed out that at Wookey Hole, as well as at Creswell, hyænas, rhinoceroses, horses, and reindeer were most abundant among the lower animals; and I believe similar evidence is furnished by other localities.

During the whole period, in which the various layers of clay, and sand, and earth, etc., were being formed in the

caves, it appears that man was present as a contemporary of the above named animals in the Creswell district, in each bed as it was successively examined, implements of human workmanship were found in intimate association with the Mammalian bones, and it is the connection of man with the fauna of this period, and the evidence furnished by the Creswell caves regarding the early stages of human culture in North Westen Europe, that has given the discoveries we have been enabled to make, their great importance. Simple and rude implements of quartzite which were the only ones found in the lowest deposits of the caves mark the earliest appearance of the old Palaeolithic savage in this district, that he belonged to the same race which has left the somewhat similar implements in the lowest beds of some other caves in this country, and also in France, as well as in the river gravels, there can be I think little doubt; little by little a certain progress in the art of implement making is observed, flint roughly chipped, gradually supersedes the more clumsy quartzite pebble, and as we rise from the lower beds of the caves to the overlying cave earth and breccia, this advance in "primitive culture" becomes strikingly manifest, the carefully trimmed flake, the spear or arrow head, the delicate flint boring tool and other implements and weapons entirely supersede the quartzite hammers, and rough flakes or splinters of the first human inhabitants of the caves, whilst the bone awl, and needles, and the evidence of a certain amount of artistic perception manifested by the engraving of a horse's head on bone, enables us to correlate these later cave-dwellers with the hunters and fishermen of La Madeleine and other foreign caverns, whose wandering steps took them, some along the southern valley to Kent's Hole, others along the course of the great eastern river and its tributaries, as far as the forest district of Nottinghamshire and Derbyshire. Here whilst pursuing the horse and the reindeer, or

the hare, man would be frequently be brought into conflict with more formidable antagonists—the savage hyæna, and other carnivora would not be driven without some amount of difficulty from their fastnesses in the caves and glens of the forest, and it would be not only the hyæna and the wolf that man would encounter in his struggle for his early cave dwelling; but the bear and the lion and even the dreaded Machairodus would now and again oppose him. That this latter animal was living during Pleistocene times in England, there can I think be little doubt, although when first recognised amongst the animals found in Kent's hole, it was considered that it might after all be an accidental occurrence there of a fossil of Pleiocene age, it has been placed beyond doubt that the commonest Pleiocene Machairodus was of a different species, the Machairodus latidens, the only species of Pleistocene age differs in several important particulars, especially in its dentition from the cultridens of the preceding period, at the same time it appears to have been a somewhat rare visitor, besides Kent's hole, Creswell is the only other British locality of late Pleistocene age, where it has been discovered, and in France the only known remains have been found in a river deposit in Auvergne, and in the Jura, in the cave of Baume. Whether with his stone weapons, man always proved victorious in his strife, we cannot tell, but from the presence of hyæna remains in the caves in all the various beds, it appears that they could only have been temporarily occupied by men, and that the hyænas and other wild beasts of prey, were their more constant inhabitants.

We will turn our attention now to the cave which has been last explored—Mother Grundy's Parlour. From our previous inspection of this cave and the unmistakable evidence it presented of having been considerably disturbed at various times, we were deterred at first from undertaking its exploration; but towards the end of 1878 Professor

Dawkins called my attention to the fact that teeth of the hippopotamus had been recently found there by Messrs. Duffy and Gain, and he proposed that we should without any further delay dig the cave out. This was done under the careful superintendence of Mr. Knight, of Owens College, and with results of considerable interest, as the beds found in this cave seem to take us back to a yet earlier period in the history of Creswell than that which has been traced in connection with the other caves.

Mother Grundy's Parlour is a small shallow chamber in a crag near the eastern extremity of the ravine. It is only some 35 feet deep by 22 feet in width; but in its eastern side, near the back, a small fissure, about 4 feet wide by 2 feet 6 inches high, was seen to be blocked up by earth and rock, and this cavity, when opened, proved to be a long narrow passage, which in our report has been called Chamber B.

In the principal Chamber A, the greater part of the old surface soil had been dug into, and was untraceable, but on the western side of the chamber a certain portion of it still remained in situ; it was but a few inches thick, and contained fragments of burnt bone, charcoal, and at its base a considerable amount of flint flakes or chips. Below this superficial layer a bed of reddish sandy earth was found, of variable thickness, the maximum being about 3 feet 6 inches, opposite to the mouth of Chamber B. It was here that the principal section was obtained, and also this was the locality of the more important finds yielded by this cave. The sequence of the beds, as observed at this point, was as follows:—

1. Surface Soil..... 4 inches.
2. Red Sand..... 3 feet.
3. Red Clay..... 6 inches.
4. Ferruginous Sand ..... 1 foot.
5. White Sand..... ?

The red sandy earth of this cave was found to contain remains of the bison, reindeer, bear, wolf, fox, and hyena, and the evidence of the occupation of the cave by the latter animal was well marked by the presence of its coprolites in large quantities. A few quartzite implements occurred with the bones and teeth in this bed. There seems to be little doubt that in correlating the deposits in Mother Grundy's Parlour with those of the other caves, we must consider this sandy cave earth as the equivalent of the red sand No. 4 in those caves.

It is in the underlying beds of red clay and ferruginous sand that we are introduced to an earlier stage in the animal life of the district. The sandy deposit seemed to occupy a sort of depression about the mouth of chamber B. It was a calcareous sand, much stained with iron, and in places the ferric oxide had formed concretions in the sand. In this bed Professor Dawkins and myself were fortunate enough on the first day of our digging to obtain several teeth of the hippopotamus in fine preservation, and subsequently other teeth, including some of the large tusk-like incisors, and also some fragments of the skull and other bones of at least three young adults were met with, with them were skulls and jaws of the hyæna, and some teeth and bones of the bison, and the teeth also of the rhinoceros leptorhinus (Owen).

Turning to chamber B it presented no particularly new features. It was filled nearly to the roof, in places quite to the roof, with deposits similar to some of those just described,—viz., the red sandy earth and the clay, the chief difference consisting in the absence of the surface soil, of the lower ferruginous sand, and also in the greater thickness of the red clay. The clay at the entrance to this chamber contained the remains of hyæna, bison, hippopotamus, and rhinoceros leptorhinus. No trace of man was met with in

the deposit of ferruginous sand and clay, which doubtless represent the earliest period of which any remains now exist in the Creswell Caves, a period when the hyænas were perhaps less numerous, judging from the more perfect condition of the bison and other remains, and a period when man, although possibly present in other parts of the country, had not as yet found his way to Creswell. The pleistocene history of this district appears now to be tolerably complete; we are led back to the early stage, when the hippopotamus, together with the leptorhine rhinoceros and the elephas antiquus, the remains of which latter, however, we have not met with at Creswell, were able to find their way unimpeded along the various river valleys of this country, even as far to the north and west as Kirkdale, Settle, and Raygill, in Yorkshire, when the climate was not so cold as it appears to have become at a somewhat later date, when the reindeer, the glutton, the woolly rhinoceros, the mammoth, and the horse made their appearance, together with roving tribes of the human family, the orderly sequence of beds in the Creswell Caves enables us to trace as it were step by step the progress of mankind in this district, and to picture to ourselves some of his surroundings.

There is only one other point that need be brought before you, and that is the discovery of fragments of four human skeletons in the red sand. Two of the skulls found—one in chamber A, the other in chamber B—belong to two different types, the former being Brachycephalic, the latter Dolichocephalic. It is tolerably certain that neither of these skulls can be considered to have been contemporaneous with the extinct fauna. They may have belonged to the subsequent Neolithic age, to which, also, various bones of animals found scattered in the same bed may perhaps be in part assigned. The fox and the badger have much disturbed this deposit

at different times; and even in chamber B, where, owing to its complete filling up by the various beds, it seems to have been impossible that man could in any recent period have found access, yet the human remains may have been carried there by the fox and the badger at a period posterior to that when the bison or the hyæna was an inhabitant of the district.

Amongst the more recent animals, the remains of which were found scattered here and there in the upper portions of the floor of Mother Grundy's Parlour, were the wild cat, the dog, the fox, the marten, the badger, the stag, the roe, the horned sheep and goat, the Celtic shorthorn, the pig, the hare or rabbit. No trace was found in this cave of the presence of the Roman civilisation, some relics of which were preserved in the surface beds of the Robin Hood and Church Hole Caves, which were doubtless made use of by the persecuted refugees during the disturbed period which followed upon the withdrawal of the Roman legions, when the unwarlike though semi-civilised Britons were left a prey to numberless hordes of invaders, which they were powerless to resist.

Professor Boyd Dawkins said I have here upon the table a few of the specimens which have been alluded to this afternoon. In the first place, I would just ask your attention to this very remarkable series of remains of the hyæna, which were found in the lowest bed, along with the remains of the hippopotamus. There is also another specimen which I should like to put before you. I have no doubt that some here are perfectly aware that certain hard words—which fortunately break no bones,—have been drawing attention to these Creswell explorations in the Manchester press; and the hard words have more particularly attached to two things, which have been alluded to this afternoon. One is the discovery by Mr. Mello of the remarkable

engraved bone; the other relates to the discovery of the Machairodus by myself, and in both of these cases it is insinuated, that there was a "fraud, or hoax," or "plant," or something of that kind concocted by some one or another. The principal ground on which those statements were made, is that the Machairodus, was perfectly dry, and without matrix at the time when I first of all showed it to those persons who have used the hard words. Now, with regard to the first point, I assert that the specimen was not dry, but was wet—so wet that unfortunately when I brought it home, it split to pieces in drying; and if any of you care to examine the specimen you will see where it has been joined. With regard to the second point, that relates to its perfect cleanness and the absence of matrix. I assert also that the matrix is ill attached to it. If you examine the serrated edges, you will see the red earth sticking to it, as it was at the time of discovery. With regard to the asssertion that there was no red sediment in that place,—I think Mr. Mello has satisfactorily disposed of that by the consideration, that this chocolate coloured deposit when wet, is very frequently red. As far as my own experience goes, when that material which dries a chocolate colour, is wet, it *is* red. If you compare the specimen with the rest on the table, you will at once see that the matrix, and the whole appearance is of the same sort as the appearance and matrix and condition generally of the other remains found along with it. With regard to the range of the Machairodus, I would add two localities to those which my friend has put before you. The Machairodus is a genus which began to live in the Meiocene age, in America and in Europe. In the Pleiocene period we have several species ranging over France and Italy, and also living in this country. In the forest bed of Cromer, Prof. Ray Lancaster has determined one solitary specimen of *Machairodus latidens*. Mr. Mello has already mentioned

to you that the animal has been met with in Kent's Hole; and it is remarkable that the three teeth discovered there should be most extraordinarily like that we found in the Creswell Cave. It has been found also, as Mr. Mello observes, in two places in France; and, lastly, the only specimen which I have been able to detect in any other collection in any part of Europe is in the museum at Florence. There I saw in 1876 a most admirable specimen of *Machairodus latidens* which had been obtained from the Pleiocene of that district.

The animal must have been exceedingly scarce, or we would have more traces of it, and it is an extraordinary thing that we should not meet with any other remains of it in this country than merely a few teeth—perhaps as many teeth as you may count upon your fingers. Certainly not more than ten teeth have been discovered altogether in this country, belonging to the Pleiocene and Pleistocene age. It is, therefore, exceedingly interesting to be able to prove that this animal was an inhabitant of the Cresswell region in the Pleistocene age.

The sequence of events in these caverns, as Mr. Mello has pointed out, constitute their chief interest. We have met with these remains in various parts of this country and of France, in separate caverns, but it was not until the deposits at Cresswell were brought into correlation one with another that we had definite and precise evidence of the sequence. We did not know until we had this series of remains in Mother Grundy's Parlour, that the hippopotamus and the leptorhine rhinoceros, the hyæna and the like, really were in this part of the world before the reindeer and other creatures were here. Of course it had been guessed at before, but this is the first bit of direct evidence we have in this country; and I have no doubt as cave-exploration goes on (and I am sure there are plenty of caverns to be explored

in various parts of this country,) that that sequence will be proved in other places.

Mr. PLANT considered that as the alleged finding of the Machairodus tooth was still a controverted subject it was not fair to introduce it at this meeting, when the contending parties on the other side (especially Mr. Thomas Heath, of Derby), had no notice of the intention and no invitation to be present.

The CHAIRMAN (Mr. Binney) said that when the paper was printed he was sure the Society (as they were always in the habit of doing) would be glad to hear and to discuss what might be said on the other side.

MR. PENNINGTON asked Mr. Mello whether he supposed, seeing the nature of the deposit in which the leptorhine rhinoceros and the hippopotamus were found, they might have been introduced by the hyæna, or whether they were, in his opinion, introduced by the action of water. He understood, from Mr. Mello's description, that they were found in the thick clay deposit, which might, and probably was the result of the gradual percolation of water. That question he can easily answer by stating the character of the bones—how far they bear marks of the dental operation of hyænas.

Mr. HORSFALL said the most interesting part of the paper, to him, was that relating to two human skulls. The discovery of human remains in caves in this part of the country was rare. They were, however, found at Creswell, and their character was described by Mr. Mello. The question which occurred to him was whether, if the hyænas could drag into the caves such large animals as the rhinoceros, and devour them, there was not an equal probability that they would also drag in human beings? On a previous occasion he put this to Professor Dawkins, and the explanation as to why gnawed human bones were not found was that these bones might have been entirely devoured by the hyænas. If that

supposition was correct, the discovery at Creswell of human remains was very remarkable, and added very materially to the interest of Mr. Mello's paper.

Mr. MELLO said that the remains alluded to were found near the surface, and in disturbed soil.

The CHAIRMAN thought the locality of Cresswell, with its small stream, a very unlikely one for the hippopotamus to have lived in. Then how so huge an animal could have been dragged into the cave by hyænas was a very difficult subject.

Mr. PENNINGTON said the hippopotamus had been found in a still more unlikely locality, namely, Dove Holes, near Buxton.

The CHAIRMAN said the only specimen he ever heard of from Dove Holes was brought to the Society by Mr. James Meadows, who presented it to them. He (Mr. Binney) went many times to the place to get the history of that tusk. It was said to have been found in some sort of a crevice, and that was all the information he could get.

Professor DAWKINS: With regard to the occurrence of human bones in caves, in this country, as far as I know only one solitary human tooth has been discovered in any of the ossiferous deposits of the Pleistocene age; but in France there are several caves in which fragments of human bones have been met with. In no case, however, has a perfect human skeleton been met with belonging to this age. I can account for it only by supposing that men were very scarce and hyænas very abundant, and that they ate most of the men up. With reference to the hippopotamus remains being found in the caves, it was the habit of the hyæna to hunt in packs, and there was nothing, to my mind, impossible in a pack of hyænas mastering a hippopotamus or any other big animal and dragging its body into a cave.

Mr. MARK STIRRUP enquired whether it was not possible for the bones in question to have been introduced into the cave by the action of water.

Mr. PENNINGTON said he would like to ask Mr. Mello whether the fissure, shown in his section, was not very much lower, horizontally, than the mouth of the cave. The question put by Mr. Stirrup bore somewhat on this, for it appeared to him if the bones were carried into their resting place by water at all it was by water which flowed down the valley, past the mouth of the cave. It struck him that that was the more likely way of their getting into the cave than through any fissure from above.

Mr. MELLO: I think Mr. Pennington is right there. The fissure is lower—if it is to be called a fissure—lower as to its roof than the roof of the main cave; and as far as I could see there is no trace of the fissure extending upwards. It seems to be a solid flattish roof. The long chamber ended abruptly, and bore no trace of being continued to the surface. I think there can be no doubt, from the presence of the hippopotamus in this and other districts in the interior of England, that the rivers, at that period, were far greater in volume than they are at the present day. The hippopotamus could never get up the little stream which now flows through the ravine; It would then be a river of considerable size, and subject to periodical or occasional floods; and those floods might wash the remains of animals—the hippopotamus and some of the others—into the cave, whilst at the same time it is not at all improbable that remains of the same and other animals might be dragged there by the hyænas, as well as carried there by the floods. Professor Dawkins, I think, has answered the chief points with regard to the human remains found in the caverns, and he has himself suggested another reason why the bones should be very few and far between—that is

owing to the probable habits of those early men. If they were a race in any way connected with the Esquimaux of the present day, as seems not improbable, then their habits would be similar to those of the Esquimaux: they would never bury their dead, but leave them exposed, to be carried away or torn to pieces by wild beasts. My paper is simply intended to bring forward the later discoveries at Creswell and thereby complete the previous paper read before the Society in 1876.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XV. SESSION 1879-80.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 24th day of February, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

E. W. BINNEY, Esq., F.R.S., Vice-President, in the Chair.

Mr. Richard Barton, jun., Westleigh Lodge, Leigh, near Manchester; Mr. John Thomas Boot, Mining Engineer, Westfield House, Sutton, near Mansfield; Mr. Theodore Drayton Grimke, jun., Clifton and Kearsley Collieries, near Manchester; Mr. John Speakman, Colliery Proprietor, The Walmsleys, Leigh, near Manchester, were elected ordinary members.

ON CONCRETIONARY NODULES OF LIMESTONE, AND FOLIATED MOULDINGS, IN THE PERMIAN MARLS, NEAR LEIGH.

BY J. BESWICK PERRIN, F.L.S., &c., and JOHN PLANT, F.G.S.

The foliated mouldings which have been found by Mr. Perrin, in the Permian Marls, as far as my knowledge and researches extend have not hitherto been described. The only published notice I can find, which might probably have related to them, or to the concretionary nodules of lime-

stone, is in a description of a Geological Excursion to Leigh, Bedford, and Peel, on the 5th May, 1859, by E. W Binney, F.R.S., it appeared in the columns of the *Manchester Courier*, for during that year the printing of the transactions of the Manchester Geological Society in the regular form was discontinued.

The concretionary nodules may be described as presenting upon a cursory examination, an external crust of indurated red marl, enclosing a nucleus of a dull pale grey or light red calcareous cement traversed by cracks, after the manner of Septariæ filled with crystalline spar (carbonate of lime), and sparingly disclosing a black carbonate of iron in a string of minute globular grains. Upon qualitative analysis the internal cement shows abundance of the carbonates and phosphates of lime, an alumina oxide, phosphoric acid, with carbonate and peroxide of iron. Part of these are characters which can be said to be common to concretions, ironstone balls, nodules, and septariæ, found in the Carboniferous, Permian and many Mesozoic rocks, and which have received attention, and been well described by competent authorities.

The aggregation of calcareous, siliceous, or aluminous matter into lumps or nodules, and the radiating or concretionary balls—spheroidal concretions of Sedgwick,—assumed by magnesian limestone subsequent to deposition are fully explained features, well-known to most geologists.

These nodules from Leigh have been obtained in great numbers by Mr. Perrin, from the upper part of the 66 feet of Permian Marl, whilst the foliated mouldings occur in the lower part of the same stratum.

The nodules are found lying in two or three layers in the marl, but not in very regular order; they vary from one inch to one foot in diameter, and proportionately in thickness and weight, the large ones being 10 to 27 pounds in weight.

Generally they are of a circular discoidal form, but vary to an ovoid; they rise from the edge to the centre by a sucession of well defined concentric layers, almost as regular as lathe turnings, so that each surface has the aspect of a debased dome. In some of the large specimens the surfaces between each layer are marked all round with regular depressions, like thumb marks impressed upon the edges of an unbaked crust of a pie. These depressions at times cover the surface with a reticulated ornamental moulding, and are very characteristic; others are smooth and show but few of, and very faintly, the concentric layers; they are light brownish red, mottled with the grey of the cement.

A section of a large one shows how simple is their structure, and leads easily to a detection of their origin. The nucleus is a lenticular mass of amorphous calcareous cement harder than the crust; it is ramified with cracks which are lined with fine crystals of lime, these first-formed nodules may have hardened by exposure to the sun and air, afterwards, or even simultaneously, being rolled in several layers of calcareous pasty red marl, and in time deposited within the stratum of the red marl. It is quite probable that subsequently by the action of heat and loss of water, the pasty crust in drying, contracted, and so covered the surface with the corrugations so like to thumb marks, a result so often seen in the cooling or baking of cements, in lime casts, and clay pottery works.

The deposition of isolated nodules in separate layers is a common feature in calcareous strata, and those found at Leigh do not present any departure from this physical law.

Some of the Permian species of shells are found both in the nucleus and in the outer coating of these nodules, but only imperfectly preserved. The smallest nodules are mostly smooth nuclea of cement not having acquired the pasty coating of marl.

Similarly shaped nodules, but without the coating of marl, occur in the sandstone and shales of the coal measures. They are composed of fine grains of silica, strongly impregnated with iron pyrites.

The foliated mouldings may be described as flattened, discoidal, lenticular, or double convex bodies of indurated brownish red marl having an irregular but smooth or polished surface like the well-known polish of slickensides on shales and marls, the bodies vary in size and in thickness. Their diameters are from one inch to ten inches, and they are from one-eighth of an inch to one inch in thickness. The surface is very uneven from the conchoidal mouldings. In many specimens there is a deeply depressed centre (not always on both surfaces) from which radiate four or five abrupt-ending petal-shaped mouldings, which rise for about two-thirds of their diameter, then bevel off to their outer edge rather abruptly. The edge is consequently sharply compressed and thin, although not regular nor continuous all round. In a few specimens the centre is filled up with a disc of marl, giving some of these bodies an aspect that readily suggests a fossil "marygold flower;" others bear a resemblance to the flattened seeds of a large leguminous plant of foreign growth.

After a most careful examination of their material and internal matrix, there is not to be detected the slightest trace of organic structure. They are composed simply of the red marly mineral material in which they lie embedded, in fact so completely are they inorganic in structure like the marl, that they contain similiarly the remains and casts of shells common to the Permian marls, such as Schizodus, Bakevellia, and others.

When a lump of the red marl is broken up and further desiccated (in water the amount dissolved is small,) the fragments uniformly present a semi-conchoidal fracture, and have a tendency to break into crude-rounded nodules; the

discoidal foliated bodies exhibit a similar result when treated in a similar manner.

The discoidal bodies are found sparingly embedded and interspersed in the thick stratum of marl, suggesting the idea that they may have been embedded when the marl was being deposited, but I think that would be an erroneous explanation of their origin. They possess no evidences that I can detect of having been primarily concretions rolled into their discoidal forms and hardened by exposure to air and heat, and then embedded within the marl; they rather, on the other hand, by an examination of their characteristics, lead to the conclusion that they have, to speak unscientifically, grown into form and developed their lenticular foliations after the marl was deposited, and considering the inherent tendency of the whole deposit of the marl to nodular and discoidal crystallization in its structure, I see no difficulty in regarding these convex lenticular bodies to be the result of a peculiar and abnormal crystallization of small portions of the marl within the great bulk of the matrix.

These beds of Permian Marls were originally deposited in the form of fine mud deeply coloured with hæmatite iron in solution in the waters. They have become indurated and acted upon by enormous pressure and its accompanying heat. They have been subjected to upheavals and internal action of various kinds, and probably by the loss of moisture and the agency of pressure and heat have undergone changes which have brought about their present structure and arrangement, giving rise to the lenticular foliated bodies, and to the crude conchoidal crystallization prevailing through the whole of the stratum of marl.

They appear not to be entirely peculiar to the Permian marl, as I possess one black specimen identical in all respects except colour, taken out of the shales of the upper coal measures at Ardwick.

Mr. PERRIN said that the interest in these nodules and mouldings did not belong exclusively to this district, but had been talked about for a considerable length of time in other districts as well as in Lancashire. Duplicates of some of the specimens lying on the table had been sent to different geologists in London and elsewhere, but not one of them had been able to give a satisfactory opinion as to what they really were. The nodules were found congregated in considerable numbers in the Permian strata at Westleigh. He was not aware that such deposits had been found in large numbers in any other part of the country. As to the position of these nodules. A few isolated ones, which had evidently been denuded in glacial times, were found in the boulder clay, with specimens of granite and beautiful quartz specimens, but only for a short distance. Below these drifts they got the pure red marl, in which at a depth of five or six yards they came to these nodules. Beneath in this marl bed they found peculiarly foliated mouldings.

Mr. PLANT added that Mr. Perrin had brought another specimen, which showed the peculiar semi-crystallization of what was known as "cone-in-cone," and he had brought a specimen to show that by pressure the structure of cone-in-cone, could be produced. Other specimens of the concretions had been found at Patricroft, and in other localities of the Permian marl deposit.

Mr. AITKEN said that, the essayist had, notwithstanding his laborious researches, been unable to suggest a way in which the nodules had been formed. He thought they would all be in the same predicament that afternoon. He himself had regarded these nodular concretions as septaria, and he thought there were some evidences that bore out that idea. The foliated mouldings were very peculiar. He possessed one about three-quarters of an inch in diameter which had been in the possession of Mr. Carruthers, of the British

Museum, whose idea was that it had originated through an accumulation of gas near the surface, the accumulated gas forming a bleb, and thus caused the marks on the surface of the stone. Whether that was a sufficient explanation he could not say. Mr. Carruther's paper on the subject, of which he preserved a copy, is still in existence.

Mr. PERRIN said that the specimens presented the same features, and it was a characteristic of them that their features became plainer as the specimen got larger.

Mr. PLANT said that he was very much surprised to detect not the slightest trace of magnesia in them. These so-called magnesian rocks on analysis reveal no traces of magnesia.

The CHAIRMAN (Mr. Binney) said the origin of nodules is a matter that has never been satisfactorily accounted for, and concerning which there are a great variety of opinions.

Mr. M. STIRRUP asked Mr. Perrin whether the specimens always appeared in the same position in the deposit.

Mr. PERRIN said that as far as his observations went they generally lay end upwards.

Mr. STIRRUP: I suppose they may have been subjected to pressure?

Mr. PERRIN said that the specimens had, he thought, been subjected to pressure. The markings in the large specimens, with the exception of one, were exactly alike, and that was the most marvellous thing about them, the exceptional specimen was found close to the surface of the yellow clay.

The PRESIDENT: There is very little doubt that these nodules have been produced in a similar way to that in which nodules have been produced in the coal strata, the carbonate of lime, the lias and other deposits. They have all evidently had the same origin.

Mr. AITKEN said he should like to know whether Mr. Perrin had detected any organic matter in the nodules.

They knew that in coal deposits, fishes, shells, and bits of wood formed the nucleus, and also of the lias on the Yorkshire coast and in other places.

Mr. Perrin said that a number of specimens had been broken up, and no traces of organic matter had been found in them.

Mr. Plant said that if there had been any organic nucleus in the specimens he could not have failed to detect it.

Note.—Since the reading of the paper, my attention has been directed by Mr. J. Aitken to a paper by W. Carruthers, F.R.S., in the Journal of the Geological Society of London, Vol. XXVII., p. 448, 1871, "On Some Supposed Vegetable Fossils, with illustrations," in which are included drawings of three small bodies, identical with the smallest of these "foliated mouldings from the Permian Marls at Leigh. Mr. Carruthers' specimens came from Cape Breton, North America, Ayrshire, and South Wales. Mr. Carruthers adopted the opinion expressed by Dr. Fleming, "that "they had been produced in cavities in a comparatively soft "plastic matter by the pressure of water or gas contained in the "cavities, and that the specular aspect was the casting or impres- "sion of the fluid substance, hence he called them '*fluidcasts*.'"

This paper and its suggestions are very interesting, but I do not agree with the "fluidcasts" explanation, as it does not certainly apply to the large foliated mouldings found at Leigh.

J. Plant.

ON THE LONG WALL SYSTEM OF WORKING COAL.

By W. J. Grimshaw, F.G.S., and Herbert Phillips.

Part I.

The object of this paper is not that of drawing comparisons between different systems of working mines, but rather that of throwing into greater prominence the advantages for

which the Long Wall System is peculiar. As is well known the same subject has been treated many times, and in some cases a spirit of partiality seems to have arisen. Some people hold the opinion that such is the perfection of the system that its adoption universally would be of great and permanent benefit to the mining community, while others are just as enthusiastic as regards the "pillar and stall" system. Extreme ideas, however, are generally fallacious and tend to injure any cause. Simple statements of what has been done and what is now doing, afford the best means for forming a judgment: if a man pins his faith on any one system as being pre-eminent he feels bound (almost in honour) to uphold its claims in all places and at all seasons, and by thus doing becomes incapable of forming an unbiassed opinion. Somewhat new ground is broken in the present paper by the introduction of examples of long wall working from actual experience. These examples are not theoretical—they are from actual survey, and the plans and diagrams will, we hope, enable you to realize the position and influences affecting the development of each mine treated, as nearly as possible.

Every manager opening out a new seam aims to adopt such a system of working as will, in his judgment, most effectually minimise the natural disadvantages of the seam, and the risks of working it. Many, no doubt, are well aware, that a (comparatively speaking) bad seam well opened out and well worked, is less expensive than a good seam badly worked, and that a bad system or method well applied is preferable to a good system badly applied.

In the primitive opening out of our Coal Fields, there would be all but complete ignorance of the phenomena incidental to coal working, consequently the mode of excavating would be more experimental than decided. As experience could not guide the management, the working policy would

necessarily be a tentative one, and the method ultimately adopted, would no doubt be materially affected by accident and the temperament of the manager.

Those circumstances which now chiefly determine the mode of working would then be on the outside of the calculation. Gradient, quality of roof, amount of refuse dirt accompanying the working of coal, thickness of seam, capacity of seam for generating gas: these and other factors would have no weight in the method ultimately adopted. Not the least influential factor would be the temperament of the person on whom rested the responsibility of opening out the mine. It may be safely said that all systems are more or less marked with the individuality of the promoter or originator, just as all political policies are characteristic of the cabinets framing them.

Every system has some central point from which radiate all the modifications and adaptations of that system. Simplicity itself, the original system may be — embodying perhaps one or two fundamental ideas, but as time goes on, different experiences are brought to bear, until the outcome is a system well-nigh perfect in method and intelligibility, although it may fall far short of the best possible system applicable to the requirements and exigencies of the situation.

It is too frequently the practice to find fault with the originators of the various systems of working coal. Those in one district criticise and censure the practice followed in another. But criticism and censure are the results of accident and education, and we are so conservative and inflexible, that oftentimes we prefer the ills we have, rather than "fly to those which we know not of."

It is only when some startling event is made known, that the general practical mind is awakened, and interest excited to learn something of details. Since the publication of the

Inspectors' Reports last year, much attention has been drawn to the Long Wall System, by an important declaration of opinion by Mr. Evans, the Government Inspector for the Midland district. In Blue Book, 1879, page 107, he says:

"It is worth recording the fact that over 20 million tons of coal have been raised since the last fatal explosion, and, during the last 2 years 26,700,000 tons of coal were produced for one life lost by explosion of gas."

"The question may be asked: how are these results obtained? In my opinion, it is in a great measure due to the system employed. For the most part the 'long wall' is the recognised plan. Care is taken to fill with *débris* all places from which the coal has been extracted, so as to make it impossible at any time to have a large accumulation of gas. The ventilation is constantly kept up to the face of the workings, carrying with it any noxious gas emitted from the waste. The supply of air must be abundantly sufficient for almost any extraordinary occurrance which might probably arise."

Page 108.—"The seams of coal vary in thickness from 2ft. to 14ft., some of them giving off large quantities of gas."

It is not an easy matter to give a definition of the long wall system, as its modifications are so numerous. However, any system of working the coal in faces of greater or less lengths, and bringing the produce therefrom on roads, packed through the goaf, may be for our purpose termed longwall working. The packing of these roads, and the goaf generally, is an extremely important matter, and on it in great measure depends the success or failure of the system.

Packing.

The object of packing is the substitution of the best possible resistance to the roof in lieu of the coal taken out.

third-class quality seams require many natural advantages to enable them to be worked so as to attain the same end.

Plan I. illustrates the first approaches towards the true long wall system. In some collieries this mode is still followed, but more from necessity than choice. Its occurrence nearly always arises from the great hurry to get out some coal and to avoid the expense of headings. In the plan annexed this mode is shown.

The cleatage of the coal is at right angles to the gate-roads, and the line of roof breakage crosses the corners of the stalls. In the stalls it is required that the coal shall be worked parallel with the cleats or slines. Now as the mode of developing is by means of a leading stall, so soon as the length of a stall is excavated, it is started and works away to a distance of one or two-score yards, during which the leading stall is bearing the length of another face or cleat stall. The second is started but is of course some distance behind the first one, and so the two stalls will frequently work for years if the total length of faces be a limited one, so as not to permit of the first stalls standing until caught by the rear ones. Several disadvantages are inseparable from this system. 1st. The waste of coal by cutting in the fast ends, and the crush at the loose ends. 2nd. The greater breakage of timber by the irregular subsidence and breakage of roof. 3rd. Extra difficulty in separating the coal from the roof, for reason mentioned in No. 2. 4th. The liability of gas accumulating in the fast ends when the faces arise in the direction of the arrow.

Usually this mode of opening out a mine is avoided and various plans are adopted to obtain and retain uniformity of facing. A common custom is to head out eight or ten stalls on the level sides of the pit before commencing to work them. A more elaborate system is shewn in sketch.

This method is available with any kind of gradient, but is most rapid where the dip is an easy one, as it can then be

applied in any direction. In this mode a little attention will gather the fact that the slant opening gate crosses the cleatage at such an angle that while opening out new ground it is also advancing with the other stalls. Its great disadvantage is that it does not open out a length of face corresponding with the advance of the slant gate. Where the system can be applied in several directions at the same time, the development is quick and the result is an arrangement of workings and airways which materially conduces to simplicity and power in the ventilation, and to large production from a small area of mine. The plan gives another method adapted to hard coal seams and steeper gradients.

This method of opening out faces after heading out a district of stalls is gaining much favour. By carrying two leading stalls the gateway of the lower stalls provides a return air course and has also the advantage of allowing the strata to sink more intact than would be the result with but one leading stall.

Plan A represents the mode of working a seam the section of which is about 3ft. 3in. thickness of coal, the roof for 12ft. above the coal being Blue Bind, and the floor 6 in. to 12 in. of bats, and 3 in. to 4 in. of fireclay overlying a rocky shale. The dip is very moderate—rarely exceeding 1 in 10 or 12. The cross gates are driven every 300 yards and the stalls are 30 yards in length. There is plenty of packing material; goaf is pretty closely stowed, and the swelling of the floor soon renders it impervious to air.

Plan B shows the workings in a seam of the following Section.

Roof—Light Blue Bind	18 ft. to 24 ft.
"Jays" or Bastard Cannel ...	8 in. to 12 in.
Soft Coal or Sand.....	10 in. to 12 in.
Steam Coal	2 ft.
Clunch	4 ft.

The "Jays" are used for packing, and they are filled in with fire-clay. The stalls are about 400 links in length.

Plan C shows an adaptation of long wall to a stiff gradient and thin seams, two seams being worked. The lower seam is of 3 feet section, 3 or 4 in. of which is an inferior cannel, so valueless that it is used for making packs. The rest of the seam is made up of 10 in. of very soft coal, and 1 foot 9 in. of steam-coal. Underneath runs an irregular stratum of fireclay, 3 to 6 in. thick. The gradient varies from 1 in 4 to 1 in 8. The upper seam is 2 feet 10 in. thick, and is a strong soft house coal. Underneath is 12 to 20 in. of fire-clay and bats, which is turned over into the goaf and packed.

The gateways are carried end on. The coal also is gotten end, and will sometimes part from the roof and wall in blocks many tons in weight. The lower seam, when fully developed as projected by the dotted lines, will also work similarly. With the face it already has—about 100 yards—it is making fine blocky coal.

The greatest difficulty in connection with the working of the mine is the pitch of the measures, which greatly hinders the loading and tramming of the coals from the banks to the gateways. In the gateways three to four feet of ripping is taken, so that the horses draw the coals from the faces.

The stalls in the upper seam average about 40 yards, and are capable of producing 10 to 20 tons per day.

In the lower seam 35 yards will be the length, with a capability of 14 to 18 tons. These stalls are marked F on the plan.

The stalls marked A on the same plan are 66 yards long, and are worked face on. Their capacity is 18 to 25 tons per day of nine hours. In this seam, when opened to the extent of the projected lines, there will be about 450 yards of faces, with a productive power of 250 to 300 tons.

In the other seam, 720 yards are capable of giving 300 to 350 tons daily.

The seam is not a very fiery one, but gas quickly generates in places inaccessible to air currents. At the place marked H, which is the highest in that air district, gas will accumulate in a few minutes if the doors P P be left open, and the greatest care is needed to prevent accumulations. It is anticipated that when the headings reach the point O, under the Old Top Level, where is a staple shaft, no difficulty will be experienced in sweeping the gas out of the mine.

In the upper seam the currents are ascensional, and although the seam is a gaseous one, none is ever discovered. Fast ends, which on the rise side form a barrier to the ascension of gas are avoided, and the gas therefore rises to the up-cast by reason of its lighter specific gravity.

The roof is irregular, being rock over the upper part of the mine, and light-blue shale in the lower. After leaving the rib at such a distance behind as allows of the subsidence of the entire strata, no more trouble is experienced in dealing with the rock than with the shale roof. The goaf becomes solid in both seams at a distance of 40 to 50 yards behind the coal faces, the depth from the surface varying from 220 to 120 yards.

The system of traffic roads is by cross gates and main gates, the cross gateways being run over at 150 to 170 yards distance from each other.

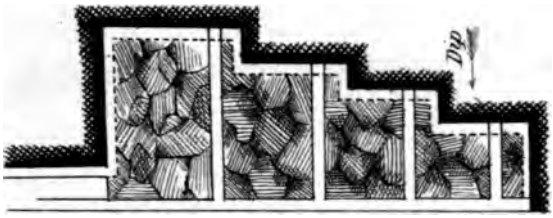
Mr. WOODWARD said that his experience had shown him that even in a mine eight or nine feet thick, to put up a packed wall was a matter of very considerable difficulty and expense, which must be materially increased in one of 12 to 14 feet, as referred to in the paper. It was difficult to find packing in those thick mines which had friable roofs. Sufficient material to make a pack eight or nine feet high, which would not be pressed down by the ordinary subsidence of the roof, was hard to get either from the roof or floor.

The CHAIRMAN said the subject was an important one, and doubtless gentlemen would like to see the paper in print before entering upon a full discussion of it. As far as his observation went, with regard to coal getting, each district had its peculiar difficulties to contend with, and what was very good in one might not be so satisfactory in another. In the neighbourhood of Chesterfield, many years ago, he saw the long wall system carried to great perfection. It was practiced by men who had been all their lives engaged on it, and who worked with remarkable skill. The subject was one of great importance, and when the paper was printed a very useful discussion might arise from it.

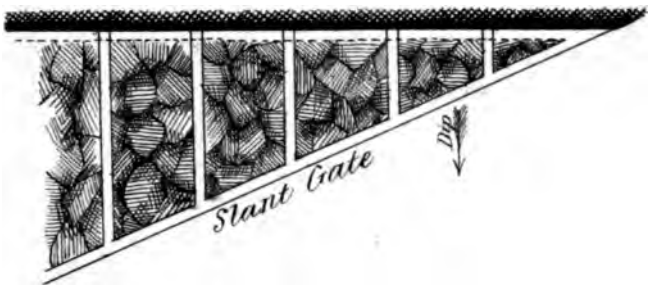
Mr. GRIMSHAW said that the plans shown had reference to the Midland district only, and most of them were taken from thin mines. He could not say that he had had any experience of 12 feet or 14 feet of coal worked in one lift by long wall; but he found in Mr. Evan's report mention made of seams of that thickness worked successfully by long wall.

The further discussion was postponed until the paper is completed and in the hands of the members.

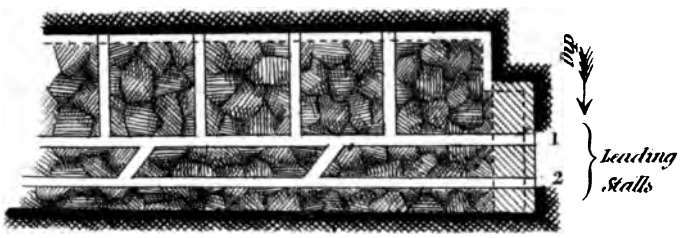
PLAN 1.



PLAN 2.

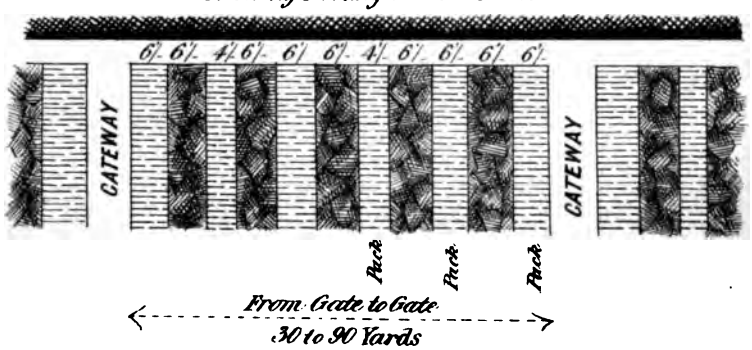


PLAN 3.



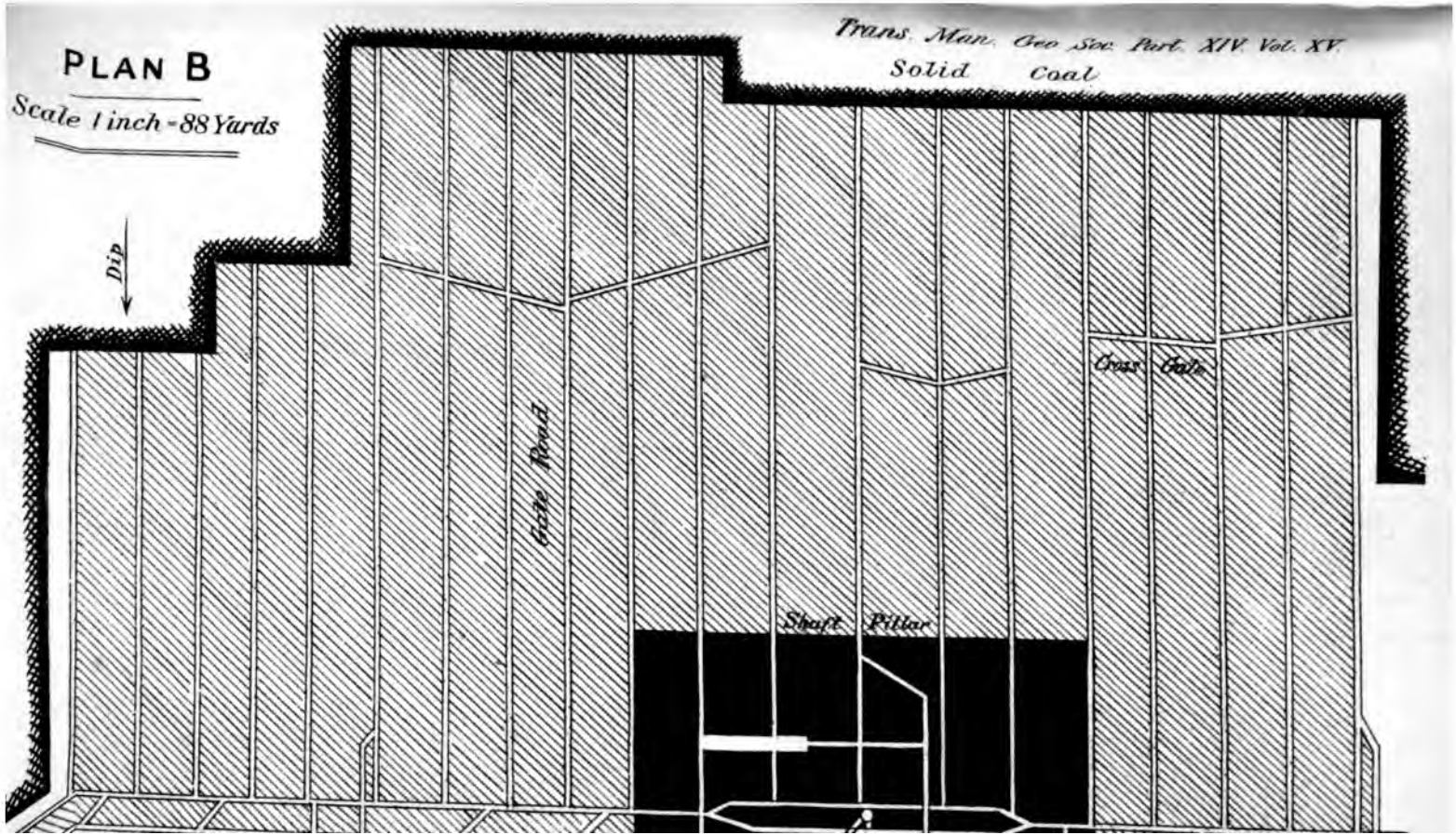
PLAN 4.

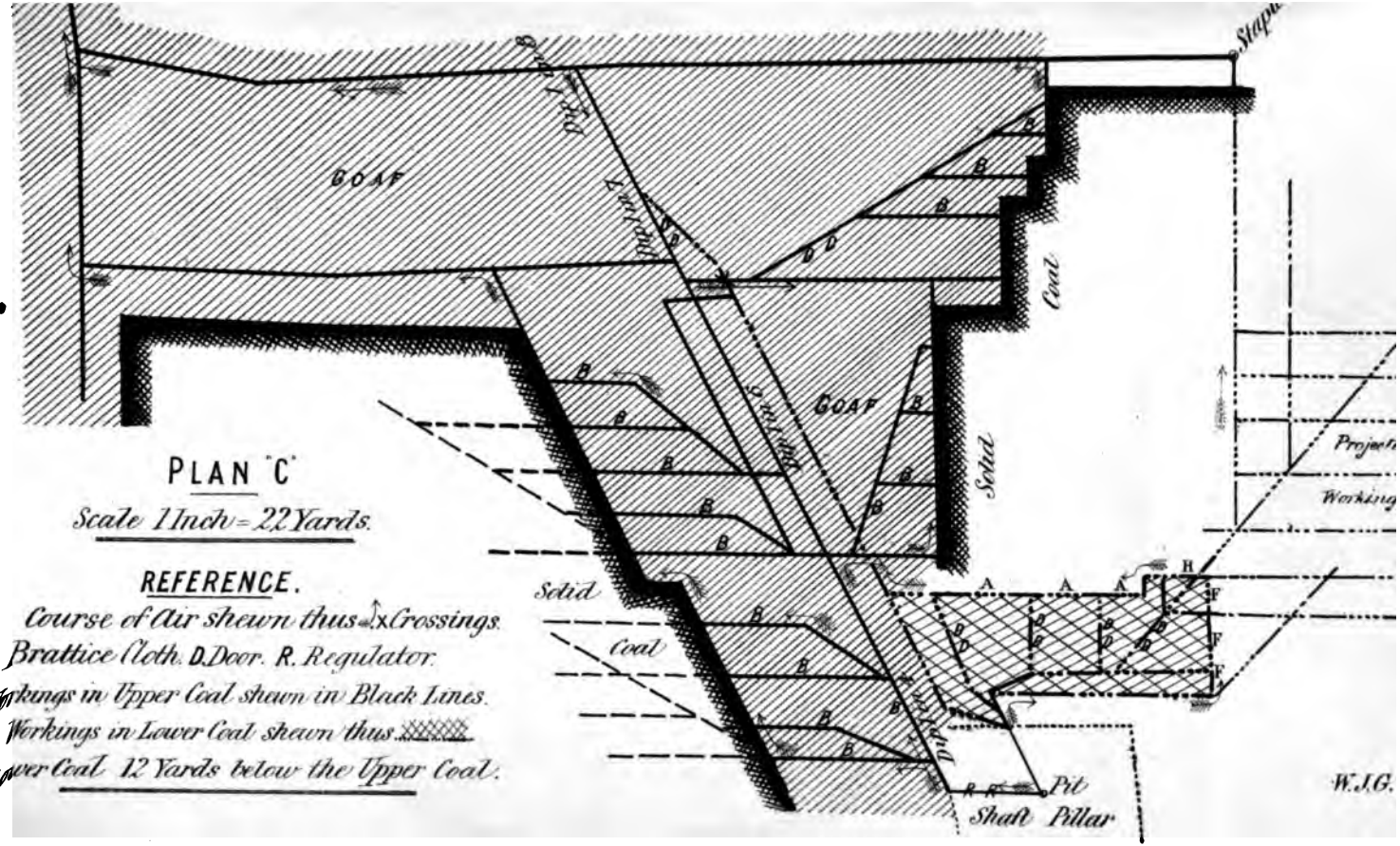
Showing Arrangement of Packs



Solid Coal

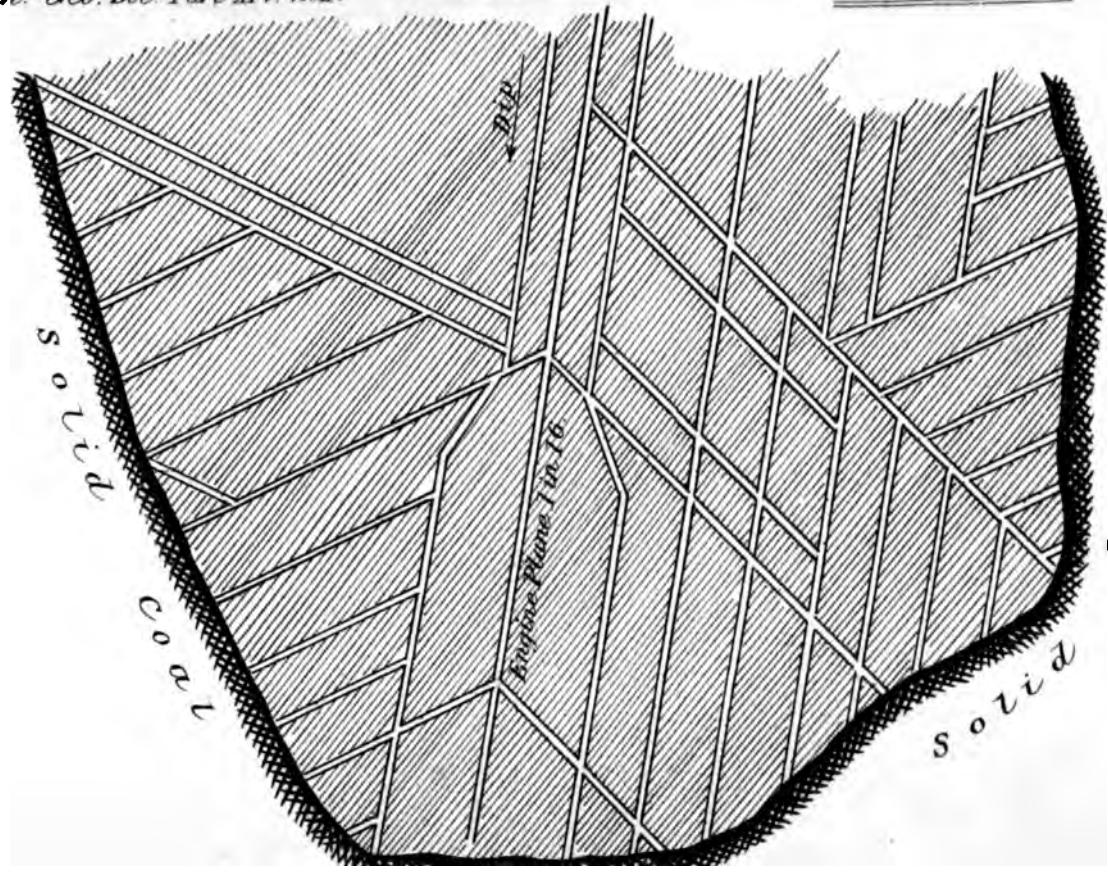
W.J.G.


PLAN B
Scale 1 inch = 88 Yards
Dip
Solid Coal
Gate Road
Cross Gate
Shaft Pillar


GOAF
Level
Dip
Coal
Solid
Staple
Shaft Pillar
Pit
W.J.G.
PLAN "C"
Scale 1 Inch = 22 Yards.
REFERENCE.
Course of Air shewn thus ⇗ x Crossings.
B. Brattice Cloth. D. Door. R. Regulator.
Workings in Upper Coal shewn in Black Lines.
Workings in Lower Coal shewn thus
Lower Coal 12 Yards below the Upper Coal.

PLAN

Scale 1 inch-



W.J.G.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XV. SESSION 1879-80.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 23rd day of March, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

E. W. BINNEY, Esq., F.R.S., Vice-President, in the Chair.

Mr. Joseph Smith Fairley, Land and Mineral Surveyor, Huskisson Street, Liverpool; Mr. James Hayes, Colliery Manager, Westleigh, Leigh, Lancashire; and Mr. Thomas Parr, Westleigh, Leigh, Lancashire, were elected ordinary members.

Prof. G. FORBES, of Anderson's College, Glasgow, exhibited his "Damposcope," or "Fire-damp Indicator," and explained its action. In doing so, he said the purpose of this instrument was to detect the quantity of fire-damp present in the atmosphere of mines. They must welcome anything that was likely to prevent those disastrous colliery explosions which occurred from time to time, and he thought it would be found that the "Damposcope" would be of very great service indeed. He was first led to think of the question in the year 1877, just after the explosion at Blantyre No. 3 pit, when a friend of his, Mr. James Young, of Kelly, described to him an instrument he

had devised to detect fire-damp; but that instrument seemed to him (Prof. Forbes) to be complicated, and one, he thought, would be preferable, which could be carried easily through the workings, and applied without delay. A new principle suggested itself to him, which, on testing, he found to be very delicate. The principle was this: that the sound produced by the vibrations of an ordinary tuning fork, which might be almost inaudible if simply diffused through the air, would become distinctly audible if the fork was placed in close proximity to a confined column of air or fire-damp, or a mixture of the two; that the maximum extent of sound would be given out, if the column consisted of pure air, when the column was of a certain fixed invariable length; but that if the air was mixed with fire-damp, the maximum extent of sound would be given out when the column was of greater and greater length, according to the proportionate amount of fire-damp mixed with the air.

Prof. FORBES then described the mechanism of the instrument, a sketch of which is appended. It would be seen that it consisted of a tuning fork and striker, a tube to contain the column of air and fire-damp, a piston to regulate the length of column, a dial, the finger of which is connected by a rack with the piston, and graduated to shew the exact percentage of fire-damp in the column, this depending exactly on the length of the column, and a thermometer to correct the reading for temperature, but graduated to show percentages of fire-damp to be deducted from the reading on the dial.

The instrument is used as follows:—The piston, which fits quite tight in the tube, is pushed quite to the top by means of the handle at the end, thus completely emptying the tube, and is then drawn back again, admitting the air or mixture of air and fire-damp to be tested; the tuning fork is then struck, and the piston is moved up and down in the

tube until the point, at which the maximum sound is heard from the tuning fork, is reached; then the percentage of fire-damp is read off from the dial, and the deduction for temperature is made, the result being the exact percentage of fire-damp in the mixture tested. If the mixture tested is pure air the reading of the dial, less the deduction for temperature, will be zero. The instrument might be used in mines to test air with which a large proportion of fire-damp was mixed, and where it might not be safe to take a lamp, as the dial face could be coated with luminous paint, or made phosphorescent, and would emit sufficient light to enable the operator both to see his way and also to take the readings. Anyone testing for the presence of gas for the first time by this instrument would probably not be able to hit off the exact percentage within 1½ or 2 per cent. of the gas present. Three or four trials, however, would yield better results, and a day or two's practice would enable a person, if there was a half per cent. of fire-damp present, to detect it. When it required six per cent. to become explosive, and when it was considered that a Davy lamp would not indicate less than four or five per cent., and then, of course, without indicating the proportions, gentlemen would see that they had in the "Damposcope" a far more accurate and delicate instrument, which would detect quantities of gas of whose presence they would otherwise be quite ignorant. Analytical tests were made which left no doubt whatever of the accuracy of the indications. He had found the "Damposcope" a most convenient and portable instrument in the mine, never suffering damage, and never seeming to be in the way in the least. For practical use therefore it was in every way desirable.

Mr. Dickinson said the Society was indebted to Professor Forbes for having come so far to exhibit and describe his instrument. That large gathering of mining gentlemen

must convince him, and anyone who had any doubt about it, that if there was an invention which would conduce to the safe working of mines, mine owners would not be slow to avail themselves of it. It might be said that there had been previous workers in the same field. They had had Mr. Ansell's instrument before them for many years, but it had never been brought into use. That instrument had several drawbacks. In the first place, so far as his experience of it went, it was not reliable. He remembered well going along with several of his colleagues to see it tested, when after waiting about an hour the instruments failed to act. An instrument which was not reliable of course no mining man would think of trusting in a mine, when the result might be a disastrous explosion. Dr. Angus Smith he found was also working in the same field. He informed him that he had devised an instrument for detecting the proportion of gas in the air, and he was very sorry that Dr. Angus Smith, could not be present to give them some account of it. He (Dr. Smith) described his instrument as being new and also useful, and those of them who knew Dr. Smith would certainly not suspect him of exaggerating the importance of his own discovery. Mr. Ansell's instrument, besides being unreliable, had another great drawback: it could not be used twice over without receiving a dose of fresh air. That alone, in his (Mr. Dickinson's) judgment, was sufficient to condemn it. It was a scientific toy, and nothing more. If Prof. Forbes's instrument would do what he stated, and enable them to measure the proportion of gas in a mine up to one and a-half per cent.

Prof. FORBES: One half per cent.

Mr. DICKINSON said that was smaller than what he was supposing. If it could indicate even one and a half it would be a valuable instrument, particularly in mines where powder was used, and where there was much coal dust, because it

was found in dry seams that a small admixture of fire-damp, such as a safety lamp might not indicate, would suffice, mixed with the coal dust, to communicate with the flame of a blown out shot, and so produce a general explosion. If this instrument would indicate what a safety lamp would not, it would be a very valuable adjunct in mines where there was not otherwise a discernible per centage of fire-damp, and where powder was used.

Mr. Clegg Livesey said that all previous instruments he had seen for indicating fire damp had seemed to him either too cumbrous or too intricate for practical use; and he was not at all surprised at their not having met with support from mining men. He was, however, deeply impressed with the utility of the simple instrument devised by Professor Forbes. They had none of them had an opportunity of seeing it before that day, but he was sure very many of those interested in mining would try it.

Mr. Dickinson inquired if one and a half per cent. of fire damp would produce a sound so audible that any ordinary person could distinguish it.

Prof. Forbes: My experience is this—that anybody at the first attempt could detect two per cent. On the very first trial of the instrument repeated readings of it would agree with each other to two per cent. at the outside; but that, with practice, after using the instrument for a few times, it could be read to one per cent. I can read a half per cent., and my ear is not so sensitive as many people's. I am perfectly certain that anybody could read to one per cent.

Mr. Dickinson said he understood that carbonic acid gas affected the sound of the instrument. Carbonic acid gas, if present with fire-damp, generally retarded an explosion, so much that a much longer cap was shown in the Davy lamp, indicating its presence, than they had if the gas was pure.

Prof. FORBES said that was a point on which he intended to have spoken upon. Two years ago he abandoned the instrument altogether, because, although he had seen how delicate its action was, when he showed it to a mining engineer he was told that the presence of carbonic acid would alter the indications of the instrument. He thought for that reason, it would be useless, and he gave up his experiments for nearly a year. It was not until, on ascertaining from the work of Dr. Angus Smith and others, the effect of carbonic acid gas, as spoken of by Mr. Dickinson, namely, that it prevented a mixture of fire-damp and air from becoming explosive, that he set to work again, to go into the theory and practice of the instrument. Four per cent. of carbonic acid, he was told, would extinguish both candles and life itself: therefore any perceptible quantity of that gas, to affect the instrument, was not likely to be met with, under ordinary circumstances.

Mr. DICKINSON said that, according to Dr. Angus Smith, two per cent. of carbonic acid would put out candles, and four per cent. would extinguish robust life.

A MEMBER observed that it depended upon the specific gravity of the gas.

Prof. FORBES: It depends on two things—partly the specific gravity of the gas and partly on the pressure of the gas. The greater the pressure of the gas and the longer the tube, the greater the specific gravity of the gas and the shorter the tube. The barometer did not affect it in the least.

In answer to a question, Prof. FORBES said that he had experimented in some very deep mines in the neighbourhood of Glasgow. One of the deepest he had been in was the pit of Messrs. Merry and Cunningham, next to the Blantyre pit.

Mr. EVANS, Inspector of Mines, said he was very much

delighted to have had the privilege of hearing Prof. Forbes' description of his instrument. If it could be brought into practical use there was no doubt it would prove very valuable, especially, as Mr. Dickinson had said, in mines where powder was used, and in which there was a mixture of coal dust. The difficulty he saw about it was that it might be too delicate an instrument for ordinary use by a working man.

Prof. FORBES said that anybody could work it: of that he thought there could be no doubt. In answer to another question the Professor said he had no reason to believe that the coal dust present in a mine affected the indications of the instrument in the slightest. The two per cent., or whatever might be the proportion of gas, would be indicated all the same, so far as he knew.

Mr. CHARLES S. JACKSON said that, speaking from his experience of some mines in the neighbourhood of Wigan, he believed the instrument would be of the greatest utility, if it did all that was claimed for it, of which he had no doubt. In a mine now being worked at Westleigh he had seldom or never seen a cap before seeing an explosion in the lamp. That arose from the great purity of the gas in that seam.

Prof. FORBES said that that was an extremely interesting point, of which he had never heard before. It indicated a field where the instrument would be of the greatest use. In reply to an observation by Mr. Livesey, Prof. Forbes said he had no hesitation in saying that the purer the gas the quicker the indications of this instrument would be.

Mr. LIVESEY said in that case the instrument would be of the greatest value, inasmuch as it would indicate exactly what the proportion of gas was, whereas now they had a very rough rule of thumb way of arriving at it. There might be a dangerous explosive mixture, and yet they would scarcely find it in the lamp at all.

Prof. DAWKINS said, as one who was totally unacquainted with mining, he wished to express the extreme pleasure with which he had listened to such an ingenious mode of applying a method of precision to measuring what before was not measured with accuracy. He certainly thought, as a mere matter of scientific inquiry, Prof. Forbes's instrument was one that was to be welcomed by them all, whether they were interested in coal mining or not.

In answer to a question, Prof. Forbes said that the present price of the instrument was £10, and that the makers were Messrs. Mc.Gillwray and Scobbie, of Anderson's College workshops, Glasgow.

ON THE LONG WALL SYSTEM OF WORKING COAL.

By W. J. GRIMSHAW, F.G.S., and HERBERT PHILLIPS.

PART II.

If part of a rigid or resisting body be subtracted in such manner as to leave an overlying portion, this portion will become subject to a more lively molecular action. In other words, the overlying portion, being deprived of its rigid support, becomes subject to an amount of disturbance, which varies in intensity according to its nature and the amount of artificial support substituted for the rigid support of the strata excavated.

When workings are headed out over a large area, the pillars have to sustain the sum total of the superincumbent weight. Assuming that coal will not bear a pressure greater than (say) 2000 lbs. to the square inch, it becomes evident that, at a certain depth, the static weight on the coal will approach the crushing point, and theoretically a small

amount of excavation would cause that point to be reached.

But here several matters require consideration—such as the nature of the roof and floor—as these are very important factors. Roof falling in a heading or comparatively narrow place, generally falls in such manner as to leave the opening somewhat in an arched form—while a roof will sometimes bend till it touches the floor, when the coal has been gotten.

Possibly there may be a difference in the atomic structure of coal lying at a great depth—but this is a purely hypothetical consideration. That depth has a very serious effect in pulverising a coal seam is well known.

The generation of gas may depend upon, or rather be influenced by, several conditions, and doubtless these conditions vary materially in different cases. When part of the coal is extracted, the remainder is subjected to an increased weight, resulting from the pressure of the upper strata and also to a lessening or removal of the lateral pressure. When this weight is on, gas is frequently given off in large quantities and continues to be given off till the extra make, due to the increased pressure has become exhausted, or the pillars have become so shattered as to be only in slight resisting contact with the roof. The zone, (if it may be so called,) of generation will extend throughout the field of pillars, so that to nullify risk it is necessary to scour all the pillar surfaces with wind. The numerous angles of the pillars render this operation somewhat unsatisfactory at times. In the long wall workings the zone of gas generation will be limited to a space bounded on one hand by the coal wall and on the other by that point at which the super-pressure has become so great upon the goaf as to resist or subdue the expansive force of the gas. Where the mine is deep and the roof flexible the zone will be narrow, where shallow and rocky it will of course be wider. From measurements recently made, the writers have found that a long wall goaf

is practically impervious to gas generation, according to the following table:—

Depth of Mine.	Roof.	Floor.	Distance of solid goaf behind faces.
75 yds..	.Flexible and soft.	.Heaves a little.	.18 to 20 yds.
100 „			
150 „	Rock and bind.		.40 to 50 „
200 „	Shale and rock bands		.20 to 40 „
250 „	Shale and rock bands		.25 to 30 „
300 „	Strong shale and rock		.40 to 50 „

Then there is also this consideration: If the goaf is open for the generation of gas it is also open for the circulation of wind. Should the goaf rise to the faces or "banks," the gas will flow into the air currents and consequently be carried away as generated. Should the other condition obtain and the goaf dip towards the "banks," an allowance of wind to go up and down the gateways will most likely be necessary. Weight or pressure accelerates or quickens the generation of gas. Supposing coal to contain the same amount of gas at all depths, and that it be of uniform texture or hardness, then generation of gas (in a given time) might be expected to increase in direct proportion to the depth of the overlying measures. This would certainly be the case; but, as a rule, it is found that seams lying at great depths have less generative power than seams lying at less distance from the surface. Mr. N. Wood (p. 14, vol x. of the "Transactions of the North of England Institute") gives an instance of this in the same seam at adjoining collieries. Allowing, however for this, the statement that generative power is in proportion to depth, will still hold good, for whatever may be the amount of gas contained in a seam, it will be generated at a quicker rate, under a heavy than under a lighter pressure. What are termed "weights" will generally increase the influx of gas. During the action of a weight the state of slow motion in which the super-strata must be, increases the pressure on the coal faces by causing a kind of grinding

action. From experiments recently made by the writers, they found that the temperature of the coal in the gate-roads was sensibly increased during a weight. Rippings are of course a considerable source of expense, and in making a road it is very necessary to take into consideration the time for which it will be needed. If a road will be required for only six months, it is absurd to make it in such a permanent manner that it will last as many years. When we come to deal with the question of relative cost, we shall find that the straightwork of the pillar and stall system has to be pitted against or compared with the goaf roads of the longwall system—bearing strictly in mind the purposes served by each, and the advantages and drawbacks of each.

It is worthy of note, that in working large pillars of coal by so-called "longwork" the packing of the goaf is not so well attended to, as a rule, as it is when there are practically no pillars, and upon the advancement of the face depends the whole output of the pit. This is not to be wondered at, for two reasons. Firstly, there is not the same need to keep the faces clear, because the mine is so subdivided that no total stoppage of operations is at all likely to take place, a comparatively safe ventilation is more easily practicable, and the inducements to pack well and thoroughly are often wanting, because a worked-out pillar is abandoned. Secondly, in many mines the material required is wanting, and cannot be obtained without thick rippings. In longwall working but few explosions have resulted from standing gas in the goaf, but instances of outbursts from the floor or roof have been comparatively frequent, and it is within the range of possibility that the system of working may render possible these occurrences more often than would the pillar and stall or other systems. In some cases, more especially where a fairly straight face is being worked, both the roof and floor may remain almost intact while the face advances a con-

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siderable distance, then if the packing has not been well attended to and kept up, when the weight comes on a considerable body of gas may be suddenly liberated. Where the roof falls close behind the packs we do not hear of the occurrence of these outbursts; but it does not by any means follow that gas is not liberated, most probably it is, but in such small and frequent volumes as to be almost imperceptible. There can be little doubt that careful and judicious packing will often prevent the occurrence of an outburst of gas. When, with a fairly straight face, a rupture of the roof takes place through insufficient packing or some unforeseen general cause, that rupture is likely to be on a larger scale and to liberate more gas than any fracture which could take place under the ordinary conditions of pillar and stall working. The true use of packing is to serve as a buffer between the roof and floor of a mine in order to prevent a too violent contact, and on its proper performance depends, in great measure, the safety of the men employed, and the economical working of the coal.

We have been kindly supplied with the following information with reference to the working of the Top Hard Seams at a Derbyshire Colliery.

SECTION OF MINE.

		ft.	in.	ft.	in.
Left for roof, unsaleable	Coal and dirt	0	6	1	7
	Comb coal	1	1		
	Clunch (Holing)			0	8½
Sold together as steam hard	Best soft coal	0	11½	3	3¾
	Rifter	0	6¾		
	Soft coal	0	3		
	Best hard coal	1	6½		
Used for building packs (difficult to sell)	Soft coal	0	4	1	0
	Sack	0	0½		
	Bottom soft (Infr.)	0	7½		
Left down for floor	Smut	0	0¾	0	4½
	Floor coal	0	3¾		

Strong clunch ..... 5 to 7 ft.
Strong stoney clunch ..... 6 to 7 ft.
Strong grey stone ..... depth unknown.

The strata overlying the mine, reading from the inferior coal left for roof is:—

	Feet.	In.
Strong Bind, with thin ironstone beds	3	0
Soft Bind	1	0
Strong grey stone	32	0
Cank (strong)	3	0

The length of the stalls is 30 yards, and the distance between the cross gates, 100 yards. The weights are violent if the face gets out of line, but subside gently if it is straight throughout the whole length of stalls. The quantity of air circulating is 89,000 cube feet per minute, in two splits of 57,000 and 32,000 cube feet respectively. The water guage is 1⅛ inch.

In ventilating longwall workings the air is taken direct to its work, and the amount of waste that requires to be aired is comparatively insignificant. Of course, the ventilation of longwall workings does not differ in any material degree from the methods in ordinary use. The only advantage it can claim is the simplicity of its arrangement. The air is now split much more frequently than formerly, and greater attention is paid to the ventilation. Having a certain amount of power at hand, colliery proprietors seem determined to utilize it fully, and large quantities of air are circulated through many of the collieries. One colliery, about 300 yards deep, working the hard and soft coals, has five splits in the hard coal, averaging 16,800 cube feet per minute each, and five splits in the soft coal, averaging 12,000 cube feet per minute each—or a total volume of 144,000 cube feet.

The discussion was postponed until the three Parts are in the hands of the members.

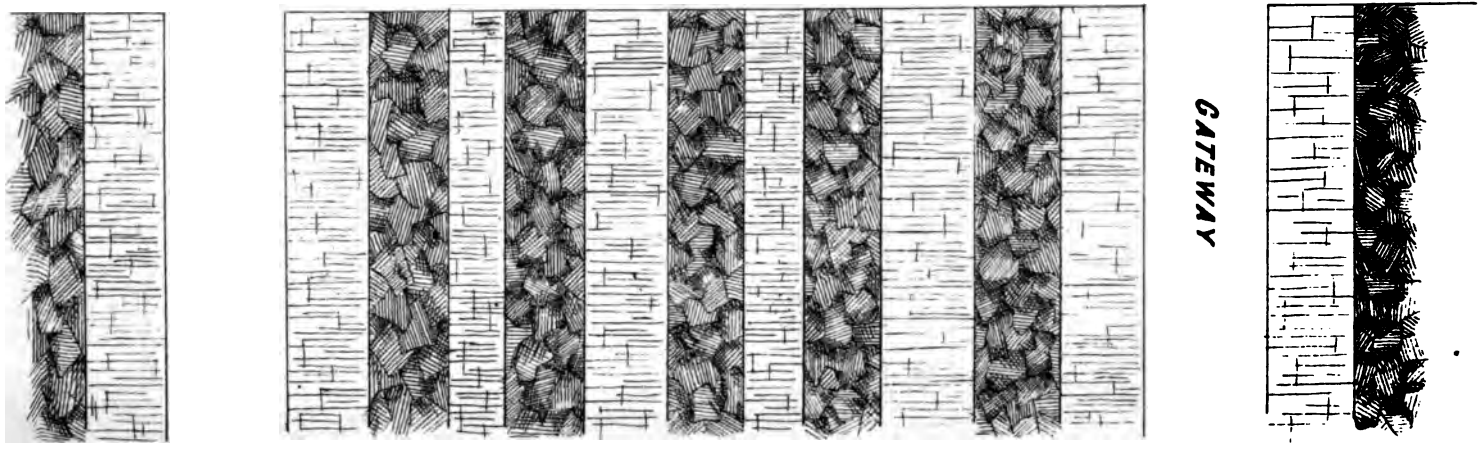
PROFESSOR FORBES'S "DAMPOSCOPE."

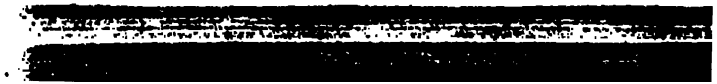
Trans. Man. Geo. Soc. Part XV Volume XV.

PLAN SHEWING ARRANGEMENT OF PACKS

Scale 8 Feet = 1 Inch

FROM GATE TO GATE 30 TO 90 YARDS.





TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XV. SESSION 1879-80.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 27th day of April, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

Professor W. BOYD DAWKINS, M.A., F.R.S., Vice-President, in the Chair.

Mr. John Hargreaves, Paper Manufacturer, Winkhill, near Leek, Staffordshire, was elected an ordinary member.

DISCOVERY OF BOULDERS.

Mr. AITKEN said: Before we proceed with the regular business, as indicated by the circular, I should like to call the attention of the Society to three boulders which have recently been discovered in this locality. The first occurred in the main sewer which is being made at Flixton. From the description I have received of it, I suppose it will weigh some two tons; it is not, therefore, a very large one. The second boulder was discovered at Urmston. This is larger than the Flixton one, being upwards of four feet in length, and I suppose it will weigh about three tons. The third boulder was discovered during the excavations being con-

ducted by the Rochdale Canal Company, in Lees Street, Piccadilly, Manchester, and is larger than the last-named, being estimated to weigh about four tons, it is now placed in Alexandra Park, in this city. In addition to these three — which have not previously been mentioned — there is one recorded by Mr. Binney in the Transactions of the Manchester Literary and Philosophical Society for the year 1877, which was an extremely large block, its weight being estimated at 50 tons. This also occurred in a sewer, and offered such decided obstruction to the cutting of the drain that blasting had to be resorted to, and, I believe, the drain eventually was carried through the very centre of that large mass of rock. The peculiarity of these boulders arises from the nature of the stone itself, which is a very fine hard siliceous grit in most cases approaching quartzite in structure. The fractured edge, it will be noticed, is almost as sharp as a knife, and, strange to say, the whole of these four boulders seem to have been derived from one source, being almost identical in texture, colour, and composition. The very large one found at Old Trafford, and described by Mr. Binney, is, perhaps, a little coarser in texture than the others. They have been examined by several geologists well acquainted with the rocks in Lancashire and the northern parts of England, all of whom experience great difficulty in deciding as to their origin. I do not myself know of any rock which answers to the character of these particular stones. Another remarkable fact is that they all seem to lie in one line, almost east and west of each other. Whether this is accidental, or whether the source from whence they came is to be sought for in that direction, I am unable to say; but such is the fact. All the boulders, I should say, are distinctly striated on the surface, are sub-angular, and roughly cubical in form.

Mr. MARK STIRRUP said with regard to one of the boulders mentioned by Mr. Aitken—that found near Piccadilly, which had since been deposited in the Alexandra Park—it seemed to have suffered a good deal of damage previously. One gentleman who was connected with the supervision of the works in Piccadilly, told him that it was very likely only a re-discovery: it was very probable the boulder was originally in the bed of the canal, and it had, he supposed, been simply got out of the way and reburied, because there had evidently been large pieces broken off it, and the fractures were apparently, not of very old date. There were still, however, very evident signs of ice marks upon the boulder. It was of large size, and very interesting to see.

FOSSIL TREES.

Mr. AITKEN said: Perhaps you will also allow me to bring under your notice the fact that in some excavations recently made at Oldham a number of erect trees have been discovered. The excavations were made in getting shale for the purpose of making bricks. The quarry has been worked I believe for about three years; and I am told by Mr. Neild, who resides near the place, and has visited it frequently, that some scores of fossil trees have been found during that period. I paid a visit to the quarry about a week ago, and found two erect trees *in situ*, one was 18 inches in diameter and about 8 feet high, and I learned that about 6 feet of it had been removed before the time of my visit. The roots spread out forming a large stool, and having been bared for the purpose of examination presented a very interesting and remarkable feature. There was another tree about 3 feet high, and of rather larger diameter; but some, I believe, have been discovered in this

quarry upwards of 2 feet in diameter, and of greater length than any I have mentioned. They seem all to stand upon one general level and in the stratum, which underlies the roots there are found a large number of fossil ferns, calamites, and other vegetable remains. The trunks are not perfectly vertical, in consequence of the rock in which they are embedded having been tilted over to an angle of six or eight degrees. Besides the trunks I have mentioned there are indications of eleven more which have been removed by the workmen. The concave surfaces left in the face of the rock are, however, still visible. Some of these, also, have been of very considerable height and large diameter. They may still be examined by any one who feels sufficiently interested in the matter. The quarry is on the north-east side of Oldham, at Oldham Edge, and near the Lower Moor Colliery.

The CHAIRMAN (Prof. Dawkins) said he quite agreed with Mr. Aitken with regard to these trees; they certainly were the most remarkable instance of the exposure of a carboniferous forest to day-light he had ever seen. He did not believe in this country we had ever had so fine an illustration of the way in which the trees grew, and of the way in which they had been preserved, as in that place. The stems of the trees might be seen close to one another—two were quite close together—conveying an idea of the dense condition of the carboniferous forest, of which they formed a part.

ON THE LONG WALL SYSTEM OF WORKING COAL.

By W. J. Grimshaw, F.G.S., and Herbert Phillips.

Part III.

In comparing modes of coal getting it is very requisite to take into account the comparative getting facilities of different coals as the getting facility has an important bearing upon the "charters" and the get per head.

It may be remarked, *en passant*, that collating the number of tons wrought per life lost, is as a test of efficient working, to a certain extent, misleading. If in one district two tons of coal are wrought as easily as one ton in another district, it should follow, other considerations apart, that the greater "get" per life lost should be in the former district. The reverse may, however, be the case when the hardly wrought seam is gotten by a superior system to the more easily worked one, but cases in which such a great difference obtained would be very few and far between. A record of the time spent under ground during the year by the total number of under ground employés might possibly be a useful record for comparison, and would certainly be an interesting one. An account of the relative progress of different systems of working coal during (say) the last ten years, would afford some valuable information, but such a review would require very careful and cautious handling.

The circumstances under which a miner can get the greatest quantity of coals, are when his thorough and continued attention and efforts can be applied to the department for which he is best suited. The skilled miner should—to obtain the best results—devote the whole of his time to skilled work.

Any deviation to work which could be done by a less

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Any deviation to work which could be done by a less

skilled workman is a loss of economy, yet this is an often-broken rule. The hewer wastes his time in loading, the loader wastes his time in tramming, and the management loses by both. The advantages of a proper division of labour are not thoroughly and generally understood. People constantly engaged in some manual occupation often attain a skill which seems marvellous to an observer. Constant practice seems to endow them with a kind of intuition or almost instinct, which is nearly infallible. It is claimed for the long wall system that the principle of adjusting the right man to the right place and keeping him there, can be adopted more readily than in any other system. Holers or undercutters are generally active young men, who are very expert with the pick. The packing and timbering is done by the stallmen or contractors. Loaders are generally more remarkable for strength than skill, in fact, the form in which many of the coals get, requires considerable strength in the loaders to put the blocks entire into the trams, thus getting rounder coal and saving the waste which would be entailed by breakage. Tramming is principally performed by boys under the direction of a few men. All these separate operations, the first three of which are, in some systems, done by the same man or men, are relegated to men who follow the same work for years. The last mentioned operation—tramming—has a very important influence on all the others. We are taking for granted that the haulage arrangements will permit of a necessary supply of trams at the different points where required for distribution. Nothing will tend more to elevate "charters" than irregular supply of trams. If the demand on the stallmen's efforts fluctuates, the maximum capability cannot be arrived at. At one time getters and loaders are wasting time in waiting for trams; at another, coals cannot be obtained from the working places. Such arrangements as will ensure a suffi-

cient and regular supply of trams to each stall are most economical. If this rule be followed, in a short time the maximum producing power of each stall will be ascertained and in this position the charter for getting reaches its minimum, and will then be ruled by market influences only.

Strength or hardness of seam has, of course, an important bearing on the getting price. This is especially the case with the "Top Hard" coal at some of the Midland Collieries. Those who are acquainted with the hard textural structure of the "Deep Hard" and "Main" coal seams, will perhaps, endorse the statement that to get them by a "post and pillar system" would be an extremely difficult undertaking, in a paying sense. The undercutting in either of these seams costs from 6d. to 8d. per lineal yard—the depth under varying from 3ft. to 4ft. It is sometimes in coal, but where possible in the fireclay. Where the "webb" or undercut coal will not come down by the influence of gravity and weight, the coal is cut to the solid, such cutting often causing it to fall right and left for some distance, or if not, giving a good "buttock" or "spurn" to blast from. This cutting is paid for at the rate of 6d. to 8d. per lineal foot.

TABLE A.

The following are the prices paid for headings in these seams—giving the width and height of the drivings :—

Name of Seam.	Width.	Height.	Price per Yard.	Remarks.
	ft. in.	ft. in.		ft. in.
Deep Hard.....	6 0	3 0	5/6	Day's Work, 3 0
Ditto	8 0	3 0	7/0	,, ,, 2 3
Deep Soft	6 0	3 0	5/-to5/6	,, ,, 3 0
Furnace Coal....	6 0	3 0	5/-to6/-	,, ,, 3 0

The charter prices are so much per ton raised, and the stallmen pay the workmen stint prices. Loading, packing,

timbering, and tramming into gate roads, are included in the charter price. As a rule ripping is also included. If nothing be paid to the stallmen on that account, the charter will run from 1d. to 2d. per ton higher, as an allowance for the same. However paid for, it is always done by the stallmen, and prices range from 3s. 6d. per yard, at 8 ft. width and 3 ft. 6 in. height, to 7s. per yard running of the same dimensions. In some mines once ripping will suffice to keep pony height between the cross gates, but in case of deep mines further ripping is generally necessitated. From numerous averages, recently taken, the wages of stallmen seem to run from 4s. 6d. to 5s. per day.

The following table shows the "Comparative Facility of Getting" of different seams as indicated by the charters, gets, &c., reduced to a standard of 1s. per ton.

Thickness of Seam.		Price per Ton.		Number of Men.	Tons got per Day.	Average Get per Man.	Standard reduced to 1s. per Ton.
ft.	in.	s.	d.			Tons.	Tons.
2	10	2	5	7	15	2¼	5·197
2	8	2	6	6	12	2	5·
3	6	1	8	8	30	3	5·
3	4	2	2	6	15	2½	5·
3	0	2	4	20	40	2	4·666
3	6	2	1	15	34	2 1/15	4·7

It is utterly impossible to give a scale of cost that would even approximately apply to the generality of mines in working. It may be safely said that a man working in a face of coal, is capable of producing (say) as a rule twice as much coal as a man working in a straight place, and in addition to this his coal will be in more saleable condition. The item of yardage in pillar and stall work is very considerable, and against this has to be set the cost of gate roads in the long wall system. Taking the case of a seam

of coal in Lancashire the amount of coal gotten in the whole is as 1 to 3 in the broken. The number of tons raised per statute acre is 7283—and the cost per acre for straight work is £485, and for wide or broken work, £460, making the cost of hewing about 2s. 5½d., which is not materially different to the prices paid to the stall men working by the long wall system. The seam, of which this cost is calculated resembles in great measure some seams worked long wall, and though the cost per ton is about the same, there is a somewhat greater proportion of large or round coal produced per acre by the long wall workings. This advantage is, however, counterbalanced by the difference in cost between hand-picking and screening. Many "sorts" of coal are made at most of the midland collieries. Indeed it is questionable if fewer would not be more economical, for in some cases though there may be a distinction between some of the qualities—it is almost a "distinction without a difference."

As an example of departmental cost we give the following analysis.

The colliery is capable of raising 1000 tons per day, and is at present raising about 4000 tons per week. The thickness of the mines in working is not less than 3 feet nor more than 4 feet.

The gradient may be averaged as 1 in 10.

The tonnage cost is	2·4	per ton.	
Overmanship and Supervision	0·430	„	
Daymen and Odd Work	1·75	„	
Haulage and Enginemen	2·5	„	
Banking (6 sorts of coal)	3·5	„	
Stores	2·0	„	
Horse Keep.....	1·13	„	
Rents	6·0	„	3s. 9·31d.

We have endeavoured to bring under your notice some

facts and theories relating to the long wall system of working, and though we have not brought forward anything new or startling, we trust that the plain description we have endeavoured to give may be of interest and use to at least some of the members of this society.

The discussion was postponed until the three Parts are in the hands of the members.

A DESCRIPTION OF MESSRS. BOOTH AND SUGDEN'S DETACHING HOOK.

By George H. Hollingworth, F.G.S.

The subject of Detaching Hooks is at the present time occupying much attention among the mining community, partly because of the prominence given to the subject by a recent dreadful accident, partly because of the interest taken in the subject by Mr. Cross, the late Home Secretary, and the circular sent out in consequence by the Inspector of Mines (and which would seem to be a foreshadowing of legislation to come), but I think, mainly because of the existence of a general feeling amongst colliery managers that some such safeguard should be adopted, so that I do not think there is any need for me to apologise for introducing this subject to your notice.

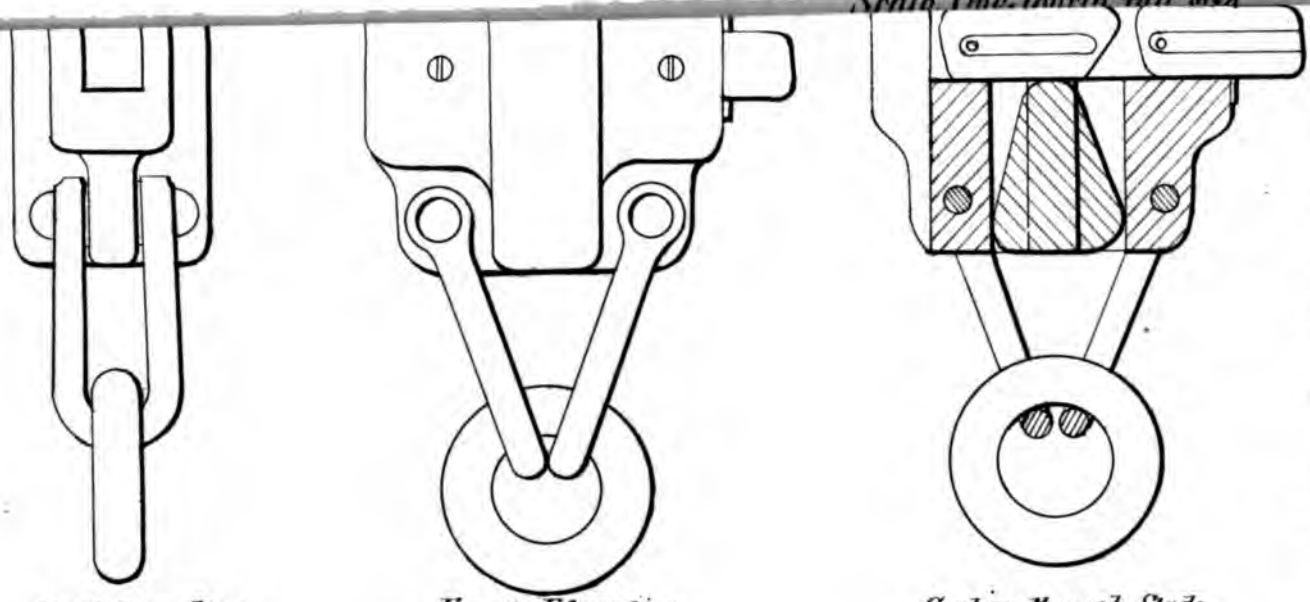
A good hook would be reliable, light and cheap, and would require little attention to keep it in good working order, and Messrs. Booth and Sugden's hook would appear to possess these qualities.

It has only recently been brought before the public, and is on quite a different principle to any other hook yet in use, and, though very ingenious, is quite simple. There are no springs or any contrivance liable to get out of order.

In ordinary winding the hook forms a shackle between the rope and the cage chain, and it cannot be put into

Messrs Booth & Sugden's Detaching Hook

Scale One fourth full size



End Elevation. Front Elevation. Section through Studs.

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operation or disengaged by anything falling down the shaft or other conceivable accidental occurrence.

It is made of cast steel so as to combine great strength with lightness and durability.

During the act of detachment 3 copper pins which serve to keep the studs in position must be sheared; but the pins are placed one in advance of the other, and the shearing action upon each pin is extended over a vertical height of six times the diameter of the pin (the action being similar to that of a cropping machine) so that the shearing is not perceptible, there being practically no strain.

Another important feature in this hook is, that it makes it impossible for what is termed a "partial overwind" to take place. The term "partial overwind" being used to signify that in a case of "pulleying" the cage has been stopped and the engine reversed when detachment or partial detachment has taken place, while the suspension apparatus has not gone far enough to get a secure hold of the suspension beam; the consequence being the release and fall of the cage. With this hook, if the engine is stopped and reversed before the box gets properly into position for detachment, the studs are forced to return to their former working position as the box is lowered through the suspension beam, by an attachment action the converse of the detachment.

When the cage has been detached by an overwind, the connection of the rope to the cage, and resumption of winding need not take more than five minutes.

Being of such recent introduction only a few of these hooks have yet been made, but one has been in daily working at Oaks Colliery for more than three months, which on being tried by a purposed overwind succeeded perfectly.

The weight of a hook, the ultimate strength of which is 60 tons and working load 5 tons, weighs 381bs.

The hook is not adapted for pits working without guides, and with round ropes, such as pits being sunk with round ropes, as it is necessary that the box should enter square into the suspension orifice, and this cannot be secured under those conditions.

I will conclude this short paper by reading the inventor's description, but the principle will be best seen by an examination of the drawings and models which are before you.

I may also remark that I have purposely avoided making comparison with any other hook, my object being simply to introduce this one to your notice.

Description of Detaching Hook, patented by Isaiah Booth and Thomas Sugden on the 20th day of November, 1879.

The apparatus is constructed as follows:—

A box is secured by the usual D links to the capping at the bottom of the winding rope, and to the cage chain, in this box the hook or bar to be released is secured, the box being shaped out to receive the same. In the hook there is a hole shaped out, into which a stud is inserted, this stud carries the load and has a bearing upon each side of the box, which is prepared to receive it. Below the hole, a wing or wedge-shaped projection is fixed upon or rather shaped upon each side of the hook, the wings being thickest at the lower end and tapering upwards. Immediately opposite the "bearing stud" and in the same line with it, is fixed another stud, which is the "forcing stud." Both studs are kept in position by soft metal (copper) pins screwed into the box, and both are chamfered off on the lower edge so as to form an inverted V when together.

The end of the "forcing stud" projects outside the box, while the whole of the "bearing stud" is concealed within the box.

Near the pulley is fixed a beam or beams to which an iron casting through which the rope passes is secured, the casting is constructed to receive the box, and to detach the rope when the box is drawn through the aperture, which is constructed on one side with a tapered slot, having its deepest part at the lower edge, and on the other side with a corresponding projection. This is so arranged that the box in passing through the aperture causes the projecting part of the "forcing stud" to come into contact with the bottom of the slot, the "forcing stud" being then pushed inwards into contact with the "bearing stud" which is thus forced outwards, and when the box has been drawn through the aperture sufficiently far, that the two studs are clear of the top, the two studs now form together an inverted V exactly opposite to the hook: the hook being slightly narrower than the V readily enters. The ends of the studs are now just clear above the aperture, the box is held at this point by projections which prevent it from going through the aperture, so that the hook is drawn through the V, forcing the studs outwards to a distance sufficient to project so far over the sides of the aperture as to hold the cage securely in position.

After detachment has taken place, the rope can readily be connected by placing the hook in the box, so that it will again descend through the aperture, by means of screws placed at the top of the aperture for that purpose. The lowering of the box through the aperture forces back the studs to their original positions, and winding can then proceed as usual. If the rope comes to a position of rest when the box is in the aperture, and the box afterwards be made to descend, in descending, the projection in the aperture forces back the studs to their working position, so that it quits the aperture in exactly the same condition as it enters, thus obviating accidents from what is known as "partial overwinding."

The patentees claim the following advantages for this invention :—

1. The load has no part in the action of disengagement. It is not continually striving to release itself from the rope.
2. There is no risk of disengagement by anything falling down the shaft.
3. No tendency to release the load, by drawing the box back through the aperture after it has been suspended.
4. Release by "partial overwinding" is entirely obviated.
5. Disengagement takes place without any appreciable strain upon the rope, the shearing of the copper pins requiring very slight force.
6. A few minutes only are required to connect and get into working order, after the occurence of an "overwind."
7. Lightness combined with strength.
8. It can be taken to pieces and examined, and be again put to work in a few minutes.

Mr. WOODWARD said the hook described by Mr. Hollingworth appeared to him to be a very clever mechanical contrivance. There was only one point which he considered weak—that was the swivel—otherwise, if kept in order, as all mechanical contrivances ought to be, it ought, so far as he could judge from the paper which had been read and the model and drawings exhibited, to act satisfactorily.

A MEMBER said it appeared to him the only strong objection to the hook was that it had always to be maintained in one position: it must be kept by the guiding rods exactly square with the aperture through which it had to pass. Again, it seemed to him the studs would be liable to rust tight and possibly break off, instead of coming into action at the moment they were required. Of course if well looked after, and the whole kept in good working condition, that danger would be obviated.

Mr. MARTIN said that several hooks of this class have been invented and patented in recent years; among them he might mention Ormerod's, King's, Fisher's, Leonard's, and others. Some of them have a great similarity in principle, but this of Messrs. Booth and Sugden appears to be different. All more or less depend upon the pin, and like everything else require attention. Of course if expected to go on working for ever without being examined and kept in order, they would very soon be a source of danger instead of safety, but, with ordinary care, there seemed no reason why the pin should be the cause of an accident, except in the case of a partial overwind, under which circumstances should be examined and put in order at once. He was informed at collieries where detaching hooks had been in use for years that several cases of over-winding had occurred, and as a rule the hooks had acted correctly, and saved not only a good deal of time and property, but also, human lives. No instance had ever come under his notice of a detaching hook being the immediate cause of an accident, although some may have failed to suspend the load when brought into action. There were at the beginning of this year a large number of these hooks in use in this district as will be seen by reference to Mr. Dickinson's annual, report, which will soon be published.

With reference to the swivel he said that they were commonly in use at many collieries, and were considered a safeguard rather than a danger when made in proportion to their work. Only a few days since he was told at a colliery of an accident having occurred in consequence of the swivel not being in use, a large water barrel in coming up the shaft revolved so much that it broke the rope a short distance above the socket.

Mr. HOLLINGWORTH said that the swivel was not an essential part of the hook at all. The pins could be replaced

in a short time, by simply screwing them out with a screw-driver, and he did not think that the apparatus was at all likely to get out of order. The whole working part was covered up, and was supposed to be a neat fit, and pretty well greased when put in; and it was also expected that at intervals of four or six weeks the whole would be unscrewed, the copper pins and studs forced out, and, when these had been greased, put together again. This was all that was required.

Mr. AITKEN asked how long it had been in use.

Mr. HOLLINGWORTH said that the hook was only patented in November last, and it had been in use at a colliery near Oldham, for the past three months.

GEOLOGICAL STRATA, AND MODE OF PROCEDURE IN DRIVING A TUNNEL AT SADDLEWORTH.

By WILLIAM WATTS, F.G.S.

EARLY TUNNELS.

We have no precise data as to when subterranean tunnels were first made. It is more than probable that they were first employed to convey water for irrigation, and subsequently for the purpose of navigation.

Very few tunnels were driven in England before the time of Brindley.

The invention and perfection of the steam engine, especially for locomotive purposes, gave a great impetus to the construction of tunnels for railways to facilitate and cheapen the cost of transit of merchandise from one town to another.

Although the earliest tunnels were made to convey water long distances, few such structures have been made for that purpose in the 19th century, except in connection with waterworks on a small scale.

Piethorne Tunnel.

Piethorne tunnel was designed by Messrs. Bateman, Hill, and Bateman, to convey Denshaw water into Piethorne valley, and thus connect the existing or old system of reservoirs with the Denshaw works which are now in progress under the direction of Mr. Foster Bateman, the resident engineer.

The driving of the headings at the open ends commenced on the 18th of March, 1878, and the last length of arching was turned on the 24th December, 1879, the sinking of the two shafts proceeded simultaneously.

The shafts are circular in plan, and are 8 feet internal diameter, cased with one 9-inch ring of bricks, set in hydraulic lime. The shaft nearest Denshaw is 150 feet deep, including 18 feet of a "sump," and the shaft nearest Piethorne is 154 feet deep, including 21 feet of a "sump."

The object in sinking the sumps so deep was to prevent the winding of water from interfering with the winding of excavated material. It was afterwards found that this was a wise provision, as a great deal of water had to be contended with during the execution of the work.

The sinking of each shaft proceeded uninterruptedly to the bottom before the brick casing commenced, very little timber being used except near the surface. The manner of timbering is shewn by the model on the table. It succeeded admirably, and did not interfere with winding, as no cross timbers were required. This timbering remained until the completion of the tunnel without shewing the slightest sign of giving way.

If the material forming the sides of shafts be tolerably compact there is little danger in sinking 150 feet deep vertically before commencing the brickwork, but a practical and a careful person should have constant supervision over the work, and if he be a geologist all the better.

It is an advantage to employer and employed to proceed

in shaft sinking as here indicated when the nature of the geological formation will allow. The miners can go on and finish sinking before the bricksetters commence, and the latter can begin their work at the bottom of the shaft and proceed uninterruptedly to the surface, and the work will be better done.

To prevent the water tapped in sinking from finding its way to the brickwork, and washing the lime from the beds and joints, before it had time to set, rubble stone backing was put in behind the brick ring, in the form of a vertical drain, and carried up from the base of the shaft as high as necessary to tap the water. This plan kept the brickwork dry, and did not interfere with the setting properties of the lime, and freed the shaft of water during subsequent operations. After the completion of the brickwork the sumps were boarded with 3-inch planks from the bottom to prevent the water barrels getting fast against the framework of the sump staging and doors.

The water barrels were constructed after the pattern of a small model on the table, and contained 126 gallons. A square flap valve is fixed on the bottom, to which is attached a light chain, to facilitate its being opened on arriving at the surface of the shaft when winding water, and also to enable the barrel to fill itself when it descends into the sump without leaving its vertical position.

The bottom of the barrel was also weighted with lead to assist it to fill and keep upright, as there is danger of entanglement of the rope should it turn over and fill itself bottom upwards.

The time and frequency of emptying the sump is determined by the quantity of water flowing into it, and this depends on the state of the weather.

In about two days after a heavy rainfall an increase of water usually made its way into the workings, but with

regard to subterranean percolation no precise data can be given as the amount of water which reaches the workings, and the time that it will require to do so, will depend upon the nature of the surface soil and substrata.

Before the brick lining of the shafts commenced the headings were driven 10 yards each way, to be free of the shaft; temporary wooden lintels being inserted to support the brick ring over the headings for the time being.

The sinking of the two shafts and the driving of the tunnel were carried on by contract, by separate gangs of men, the Corporation finding implements and material. Each workman received a proportionate share of the earnings of his gang, share, and share alike. The men formed their own gang, and selected their leader to receive the united earnings and sign cheques; the only stipulation made, was for the privilege of discharging any of the men who did not satisfactorily perform their duties. The men were at liberty to close their contract any day, but it was insisted on that each shift should be worked by the proper number of men; the plan worked admirably.

Where a Corporate body undertakes to provide implements, materials, and engineering skill it is decidedly the best plan to let the work on the principle here indicated. A more intelligent class of workmen treats for employment, and each man gets the full benefit of his labour. We feel sure that the principle might be more extensively resorted to by Corporate bodies. Where a contractor invests capital in an undertaking the circumstances are changed, and it cannot be expected that he will consent to an equal distribution of earnings, not even when he works along with his men.

With regard to excavating in the tunnel the same plan was adopted as in sinking the shaft, viz.: the whole length of the tunnel (1,412 yards) was driven through before the brick lining was permitted to begin.

This plan of procedure involves a greater outlay of timber where the nature of the ground requires timbering; but on the other hand, it secures better work, more correct lines and levels, and in the end, I think, is cheaper, in addition to a saving in time in doing the work. Of course these remarks apply to small tunnels only, such as are generally required for hydraulic purposes.

Large railway tunnels involve a greater outlay of timber, and it is necessary that it should be used over and over again to cheapen the primary cost.

To avoid pumping water the headings at the three falling ends were driven on the level, the bottom being *footridded* to the proper gradient as the brickwork proceeded.

The roof of the headings in each case was worked to the true gradient, so that in a distance of 100 yards, with a fall of 10 feet to the mile, the vertical section of the heading is 7 inches less, and so on for every 100 yards driven.

Where shafts are not far asunder, as in the Piethorne tunnel, the loss of $1\frac{1}{2}$ inch per chain in driving is more than compensated for in the saving of pumping, in other words, footridding costs less than pumping.

With slight gradients and moderately soft material this method is an excellent one, but if the material be of a hard rocky nature it adds to the cost to go over the ground a second time, and the plan should not be adopted unless large volumes of water are likely to be met with.

The headings on the rise were driven to the proper gradient, and consequently no footridding was required, beyond clearing away all projecting ledges to make ready for the brick pavement.

The headings were driven square, except that the upper angles were left full to conform with the arching of the brickwork, and proceeded at the rate of 47 yards per week, working night and day with 54 men.

The temperature of the headings remained pretty constant, ranging between 54° and 55° of heat, at a distance of 200 yards away from the bottom of the shafts or open ends. At the bottom of the shafts the temperature generally stood at 52°, except directly after the winding of water when the thermometer fell to 50°, the spray from the falling water out of the barrel thus cooling the atmosphere of the shaft 2°.

The temperature of the hard shaley material forming the sides of the headings registered 52°, at a depth of two feet, after allowing the thermometer to remain in the hole 48 hours, sealed air tight with a clay cork. The hole was drilled 10 yards away from the face where the men were working, the temperature registering 55°, and at the surface of the shaft 52°, July 4th, 1879. Two men were at work, and three candles burning at the time these observations were recorded. The hole in which the thermometer was placed was perfectly dry, and was about 200 feet below the surface of the ground.

Ventilation.

Three modes of ventilation were introduced. Where the atmospheric air had to be sent down the shafts and distributed in horizontal pipes fixed at right angles to the vertical pipe placed in the shafts, fans 3 feet in diameter were employed and worked outside the engine house by a donkey engine. At one of the open ends an 18-inch hand fan was worked. At the other open end a furnace and brattice wall, 4½ inches thick, were introduced. I purpose speaking on each of these three methods of ventilation.

A fan worked by manual labour is an extremely unsatisfactory way of ventilating tunnel headings for more than a short distance from the entrance owing to the slow speed at which the fan revolves and the difficulty of keeping up a uniform speed. The volume of air sent up the workings is sufficient for breathing purposes for the men but not

sufficient to dissipate the powder smoke after blasting, and the men had always to wait some time after firing, except under very favourable atmospheric conditions, before they could return to their labour.

The air pipes cannot be carried nearer than 15 or 20 yards from the face where the men are at work owing to the danger of breaking them by the shattered fragments of rock each time of blasting. The face, however, may be cleared of smoke in about 20 minutes, but it rarely happens that the entire length of the heading can be cleared between the times of firing so that the waggoner has to breathe foul air while travelling in and out of the workings fully three-fifths of his time, in a run of 250 to 300 yards. Although objectionable, I do not learn that powder smoke is particularly unhealthy, but the men working in it look pale and oppressed. When the workings cannot be cleared of powder smoke it is extremely difficult to work the underground lines for centres, except on Sundays after the men have ceased work for about 12 hours. The state of the atmosphere sometimes rendered the ventilation of the headings very difficult even after the junctions were effected. For hours the powder smoke lingered in the workings like a dense cloud, sometimes rising to the ceiling and at other times descending to the floor and oscillating between shaft and shaft, the balance of the atmosphere being so even that the fumes could not escape to the surface until some disturbing element intervened. It is extremely disagreeable for the workmen on such occasions and makes them languid and impairs their appetite for food.

I designed a very simple apparatus which acted admirably as a ventilator in moderately strong wind, and dispensed with the fan for the time being; in fact it sent up the workings a greater volume of air than the fan was capable of doing, and needed no attention beyond opening and

closing a valve at the bottom. The small model will illustrate this apparatus.

With regard to the fans worked by steam, they acted admirably in freeing the face of smoke after blasting, but the current of air was insufficient to free the heading between the face and the shafts, and frequently for hours together it was impossible to see in advance more than four or five yards, and on some days, when the atmosphere at the surface was heavy, the ventilation seemed to depend as much on the waggons passing in and out of the tunnel as on the fans, and it was no unfrequent circumstance for a waggon to arrive at the surface of the shaft reeking with powder fumes.

These facts appear to me to prove that for a system of ventilation to be effective in a tunnel, say beyond 200 yards away from the shaft, the air pipes must be made to give out jets of air at intervals of about six yards apart.

The present system of sending all the air to the face seems faulty. When the current is too strong it blows the lights out and starves the men, consequently the fans have to be slackened in speed, and thus ventilation suffers.

So far as I was able to judge of the ventilation in Piethorne tunnel I think the furnace succeeded best; but whether it would succeed as well on a larger scale I have had no means of ascertaining.

If the furnace has a good draft, and be kept steadily burning, it appears to purify the atmosphere in the workings more satisfactorily than fans, and a more steady system of ventilation is kept up.

The fumes after blasting are not driven away from the working face quite as soon as with a fan, but the air seems to travel more regularly, and frees the workings of foul gases from end to end more effectually.

Some collieries ventilate by means of a fan formed to suck or draw out the foul air from the mines.

Air extracted in this way would immediately be replaced by a current of atmospheric air rushing up the tunnel from the shaft, as a vacuum under such conditions could not exist.

This mode of ventillation seems well suited for tunnel purposes, inasmuch as the foul air is removed at once without being allowed to travel along the tramways to escape up the shaft or out at the open end. But I have had no experience in ventilation of this kind, and therefore cannot speak of its practical uses in tunnelling. The principle is a good one, and if I am ever again called upon to drive a tunnel I should recommend the adoption of such a plan.

The bricks used in building the brattice wall and furnace can be afterwards used in the tunnel arching, so that the expense incurred is in building the walls, and the consumption of coal, which will not amount to more than a ton or ton-and-half in a week, and the waggoner can attend to the furnace as he passes in and out.

The brattice wall takes up a little room, but it can be reduced to a small rectangular drain the last 100 yards or more, which materially simplifies the process.

I see no reason why all tunnel entrances should not be ventilated by furnaces as described.

The system is not so easy of introduction at the shafts, but motive power is generally at hand at such places to work fans.

Ranging the Centre Lines.

To transfer the centre line from the surface of the ground to the bottom of the shaft correctly requires great care, and to keep the centre line when so transferred is even more tedious.

The plan of producing the centre at the bottom of Piethorne Tunnel was that recommended by Simms in his book on "Practical Tunnelling," and is remarkably correct, when his instructions are carefully carried out.

The plan consists in stretching a thin cord as far as possible along the centre line of the tunnel, the extreme ends of which are determined by the two vertical lines dropped down the shaft, and thus proceeding from shaft to shaft, and entrance to entrance, care being taken always to have the horizontal line on the same side of the plumb lines.

Two plumb lines will be sufficient to fix a third and fourth point in the centre line, and so on to the end.

In this way the Piethorne Tunnel was worked, and although 1412 yards in length and 4ft. in width, it can be distinctly seen through. This operation may be best illustrated by the model.

Brick Setting.

When all the headings were cut through, six sets of bricksetters were employed. Two gangs started in the middle of each of the three sections of the tunnel, formed by the two shafts and open ends, and worked away from each other. Two bricksetters and two labourers were required to finish two yards of arching each shift of nine hours.

The section of the tunnel is 4ft. 6in. by 4ft., as per model, and contains 487 bricks in a lineal yard.

The inlet of the tunnel is 895ft. 3in. above the sea, and the outlet is 887ft. 3in., giving a fall of 8ft., or 1½in. per chain of 22 yards.

The iron centres used for arching are shown on the drawing. They acted admirably, and are portable, and easily set up and pulled down. Each gang of bricksetters had a duplicate set, so that the last centre-frame always remained fixed until a second length of arching was turned.

Geology of the Tunnel.

The nature of the geological strata cut through calls for no particular remark.

The measures belong to the lower carboniferous series, and

mainly consist of shales at the two open ends, with grey fissile rock in the middle.

The shales, more particularly than the hard rock, are characterised by numerous partings which cross the heading at right angles in some instances, and obliquely in others. None of these were vertical, but all slanting slightly from the horizon.

Sometimes it happened, where the partings occurred, small streams of water found vent into the tunnel, and the partings were generally filled with soft earthy material.

The shales were remarkably free of fossils, but occasionally scales of fish were found along with fossil ferns, Septaria nodules, and ironstone nodules, charged with iron pyrites, and crystals of carbonate of lime in the centre.

On exposure to the atmosphere the shales soon perish, being extremely friable and carbonaceous. The water given out in the workings contains a small percentage of an hydrate of iron, which precipitates red fibrous threads on flowing over a shallow surface.

The rock is hard and silicious, and massive in places, and remarkable for the amount of iron pyrites the finely divided joints contain, none of which, however, was found in the beds.

Occasionally traces of sedgy matter were found imprinted in the rock; but I never saw a well defined fossil plant in all my searchings.

The inclination of the beds, where continuous, is very slight, inclining at the most not more than 1 in 6. The whole series from end to end are very much broken up and disturbed, especially the length between Marsh Bottom and the first shaft, some of the strata of which are tilted over and contorted.

Three thin seams of coal were met with, as indicated on the geological section; in fact coal was pierced in five

places, including the sinking of the shafts, but it is probable that only two seams exist, both of which are of an inferior quality and burn with a dull red, and are very sulphurous.

The seam of coal nearest Marsh Bottom did not appear to have the usually well defined floor clay, but it is probable that if it exists it is rotten owing to its proximity to the surface and being acted on by surface percolation.

The next seam is about 120 yards from the first shaft, in the direction of Marsh Bottom entrance. The floor clay was present in this instance, but it was very soft and shaken, the overlaying coal being of a lustrous character and much fractured, and appeared as if its component parts had been terribly broken up since deposition and hardening.

The coal represented in each of the geological sections of the shafts belongs, I believe, to the same seam, and is somewhat thicker than the other seam or seams met with beneath.

The underclay is of a soft sandy character, light brown in colour, and contains a few stigmaria ficoides, ill preserved.

The remaining seam to be described exists about 300 yards from Hanging Lees entrance, and dips towards Piethorne Valley at an inclination of about one in six, as before stated.

It measures about ten inches in thickness, and is of an inferior quality, and is supported by a hard fire clay floor.

None of the coal seams met with in the tunnel excavations possess any industrial value, so that there is no fear of them being worked in the future owing to the very inferior quality of the coal and thinness of the seams.

I must confess my inability to correlate those coal seams satisfactorily to myself. Professor Hull refers to them in his "Memoirs of the Geological Survey of the country around Oldham," and from his descriptions I infer that they belong to his "First Coal Series." But the roof of each seam, although black and carbonaceous, has not yielded, so

far as my observations go, one single Aviculopecton or Goniatite, so numerous in a brook section at Binns, on the opposite side of the valley.

A fair quantity of gannister rock was removed from that part of the tunnel between the two shafts, but no well defined coal seam was met with, and as I only examined the "tips" occasionally, I cannot say positively whereabouts the gannister was found to a few yards, but it was quite full of stigmaria ficoides, but, unlike most gannister of the neighbourhood, it was arenaceous and friable, and soon crumbled to powder on exposure.

Taken as a whole the different strata are much disturbed from their natural position, and occasionally the dip was found reversed.

If I may venture an opinion, I believe the different coal beds here alluded to belong to the "First Coal" series found immediately above the Millstone Grit, as described by Professor Hull in his "Memoirs of the Geological Survey," page 16.

The shales in places contained really good specimens of "slickensides," with shining surfaces as smooth as glass.

Fine parallel scratches are observable on some of the specimens, indicating the direction of the movement which has polished them.

The planes of stratification are polished only, and not the joints, as one sometimes sees in hard gritty rocks.

Worm tracts are numerous in a bed of grey rocks existing between No. 2 shaft and Piethorne Valley; so numerous, indeed, are the worm borings that the horizontal layers of sand are exhibited thrown up on each side of the boring that a transverse section presents the appearance of having been deposited by rippling water.

In reply to some observations by Mr. Penman as to the efficiency of the means adopted for ventilation,

Mr. WATTS said that the apparatus of a cowl at the top of air pipes, which he had described, was believed to be, and, in fact, the workmen found it to be, the most effective when there was a strong current of wind.

Mr. MARTIN said that judging from the effects of the powder smoke upon the workmen, as described by Mr. Watts, he should say that it could not be considered otherwise than unhealthy. When the men "looked pale and depressed, and felt disinclined for their food," in consequence of the state of the ventilation, he thought there could be no question that the case was, in the words of the Mines Regulation Act, one of inadequate ventilation. It was too frequently the case in driving tunnels, where ventilation was not so imperatively insisted upon as it was in mines, that men were allowed to work in places ill ventilated, those interested in carrying out the work forgetting the indirect cost it entailed, as the amount of work men could do was not equal to what it would be if the air was kept fresh and clear from powder smoke or unhealthy exhalations.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XV. SESSION 1879-80.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 25th day of May, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

Dr. Duncan, of Tyldesley, was elected an ordinary member.

CRESWELL CAVE.
DISCOVERY OF THE MACHAIRODUS TOOTH.

Mr. Heath and Mr. Plant read notes alleging the discovery of the above named tooth to have been the result of a hoax or fraud. Professor Dawkins and the Rev. Mr. Mello replied and denied the allegations.

Mr. Mark Stirrup also took part in the discussion.

THE FORMATION OF ROCK BASINS.

BY J. D. KENDALL, C.E., F.G.S.

Professor Ramsay, in his paper on "Glacial origin of Lakes," published in Vol. 18, part 3, of the Quarterly Journal of the Geological Society, shows, I think, very

clearly that lakes which occupy rock basins, such as we know in Switzerland and our own country, do not invariably lie either in simple synclinal troughs or along lines of dislocation, and that they do not occupy either areas of special subsidence or hollows produced by wave action or weathering. But I do not think Professor Ramsay's remarks on river action are quite so satisfactory. They are as follows: "running water may scoop out sloping valley or gorge, but, excepting little swallow holes, it cannot form and deepen a profound hollow, so as to leave a rocky barrier all round." With all deference to Professor Ramsay's great experience, I believe that circumstances may arise in the natural order of things when this assertion of his would be quite incorrect. Further on, an attempt will be made to show this, in the meantime it may not be uninteresting to notice one or two of the difficulties which appear to stand in the way of Professor Ramsay's explanation of the origin of rock basins by glacial erosion.

In the first place, I fail to see why the erosive action of the old glaciers should have been greater at the particular places where we find rock basins than at other parts of their courses. If these basins always occurred in the softest strata, then Professor Ramsay's explanation, so far as I can judge, would be much more probable, but, seeing that we sometimes find a basin formed in rocks of equal, or again of very different degrees of hardness, it seems to me that some other agent than ice was necessary to initate, if not to fully excavate the rocky receptacles of our lakes and tarns.

Fig. 1 is a rough and much exaggerated section of a rock basin in the bottom of a valley, similar to those that hold the waters of the English and Scotch lakes.

What there is in the nature of glacier action to produce a hollow, such as the above, *a b c*, in rocks that are of equal hardness to those all round that hollow, I cannot understand,

yet we know by common observation that rock basins have, in some way or other, mostly been formed by the removal of rocks equally as hard as those that remain along their sides. Clearly, this could only have resulted from a locally increased erosive action, but how was that increased action produced? Professor Ramsay, in the paper already alluded to, says that "sometimes in the convolutions of the strata (conjoined with pre-glacial denudation subsequent to the contortion of the beds) softer parts of the country may have been scooped out, leaving a hollow surrounded by a framework of harder rock; but, perhaps, more generally they were formed by the greater thickness and weight, and, consequently, proportionally greater grinding pressure of glacial ice on particular areas due to accidents to which it is now often difficult or impossible to find the clue." The first part of this suggestion is clearly inapplicable to the case under consideration, as rocks of equal hardness to those remaining are supposed to have been removed. The onus must, therefore, fall upon the second part of Professor Ramsay's explanation. In Fig. 1, a glacier is represented as moving over a rock basin in the bottom of a valley. Immediately over the centre of a basin the ice, *b b'*, it will be observed, is much thicker than it is at either end of that basin, as for instance, at *a a'* or *c c'*. But that being so, does it follow, as suggested by Professor Ramsay, that its erosive action would be greater at the former point than at either of the latter points, I think not. It is clear that where the ice is thickest, other things being equal, its motion must be least, as is the case with rivers. Moreover, we know that erosion is an effect of mass in motion. Mass at rest and motion without weight (if such a thing as the latter were conceivable), must both be incapable of erosive action. Again, it is evident that relatively the measure of the wasting away (erosively) of one

body by another is the friction that is produced by their movement on one another. Now friction is proportional to the pressure or weight, so that if one part of a glacier be twice as thick as another part, the friction at the former place will be double that at the latter, that is to say, if the thickness, *b b'* were double *c c'* or *a a'*, the friction at *b* would be double that at *c* or *a*. This statement is, however, modified when we take into consideration the width of the glacier. If we suppose it to be of the *same width* throughout, its velocity at any point will be inversely as the thickness, in other words, it will move twice as quickly at *c* or *a* as it will at *b* (if all the ice at each part of the glacier be in motion), so that twice the quantity of ice will come into contact with any given area of the glacier bed at *c* or *a* that there will at *b*. To put it differently, the ice at *c* or *a* being only half the thickness that it is at *b*, the *pressure* at the former points will be but half of what it is at the latter. But the *velocity* of the ice at *c* or *a* being double that at *b*, the friction at the former points is continued, so to speak, through double the distance that it is at the latter, so that really the friction at the three places is equal. That being so, it follows that the erosive action of the glacier *a* could not possibly have given rise to the rock basin *a b c*, if the valley in which it occurs be of equal width throughout.

Again, if we suppose the valley (and consequently the glacier) at *c c'* or *a a* to be *narrower* than at *b b'* the velocity of the ice over *c* or *a* would be still further increased in relation to that moving over *b*, so that the friction at *c* or *a* would be greater than that at *b* in a proportion inversely as the widths of the glacier at the respective points. A rock basin could not, therefore, be formed at *a b c* even on this supposition.

Were the valley *wider* at *a a'* or *c c'* than *b b'*, the velocity of the ice over *a* or *c* would be reduced, and would equal

that moving over *b* when the width of the valley at the former points was to that at the latter in the ratio of two to one. The friction at *b* would then be double that at *a* or *c*, and generally it would be inversely proportional to the widths at the two places. We, therefore, see that the friction at *b* can only exceed that at *c*, and consequently at *a*, when the width of the valley at *b* is less than it is at either *a* or *c*, so that the deepest part of a rock basin formed by glacier erosion should be at the narrowest part of the valley, between the upper and lower ends of the basin, that is, at the narrowest part of the valley in Fig. 1, between *a* and *c*. But this does not correspond with the facts of observation. On the contrary, it is directly opposed to them, so that it seems perfectly safe to conclude that rock basins were not formed by glacier erosion. Besides, I have never yet seen it explained how these basins *began* to be formed by glacier erosion; for until a basin had been formed, there would be no difference in the thickness of the ice at *a'*, *b'*, or *c'* (Fig. 1), so that there would be no difference of pressure and therefore no difference of erosive action. In this connection let us look at Ullswater for a short time. Fig. 2 is a plan of that lake, showing the depths at various points, in fathoms, from which it is seen that the lake consists of two basins, as shown in an exaggerated manner in Fig. 3, which is a diagrammatic section along the centre of the lake. From this section it is clear that a glacier passing down the valley now, over the site of the lake, would be much thicker over the deepest part of each basin (if the water were removed, that is, if the ice followed the rock,) than it would be over the ridge separating the two basins, but that would not be so before the basins were formed, as is indicated by the dotted lines *a b* and *c d*. Now the ridge between the basins is not formed of a harder rock than that around them, and, therefore, on the hypothesis of glacier erosion, this ridge should not have existed.

Let me now proceed to the more immediate object of this communication. A little over two years ago, when rambling among the southern uplands of Scotland, I came upon a section which at the time suggested an explanation of rock basins that, so far as I am aware, has not previously been offered, but which seems to be very much more in agreement with facts than that of glacier erosion. The section referred to is given below, in Fig. 4, and may be seen in Selcoth Burn, a small stream which joins the Moffatt Water about four miles east of the town of Moffatt.

In this section there are a number of rock basins that evidently have been formed by the action of the water in the Burn, the main current of which follows the line indicated by the arrows, as was easily seen on throwing any substance into it of nearly the same specific gravity as the water. A piece of wet wood, for instance, thrown into the uppermost basin was carried down the stream nearly along the bottom, appearing at the surface only as it passed from one pool to another.

Now, were it possible to get a sufficiently large body of water with a sufficient fall, there appears to me no reason whatever why, in this way, rock basins might not be produced large enough to hold any of the Scotch or English, or even Swiss lakes; for each of the pools in the above figure may be looked upon as a small lake, and it seems to me that we only require the same conditions as those indicated above, but on a larger scale, to produce a larger result. But where can such conditions be found? Do they or did they ever anywhere exist? It seems to me that they must have prevailed, more or less, at some time or other, in all glaciated countries. At the present time they are found in those immense rivers described by Professor Nordenskjold as flowing over the icefields of Greenland, and at places rushing down crevasses to unascertained depths below. He tells, in

Vol. 9, Geological Magazine, that he and his companions "saw, at some distance from them, a well-defined pillar of mist, which, when they approached it, appeared to rise from a bottomless abyss into which a mighty glacier-river fell. The vast, roaring water-mass had bored for itself a vertical hole, probably all the way down to the rock, situated certainly more than 2000 feet beneath, on which the glacier rested." The denuding effect of these falling waters must be something enormous, in fact, powerful enough, judging from what has been done in Selcoth Burn, to produce in the rocks below hollows as large as our largest lake basins, and I am very much inclined to think that in that way most rock basins have been produced, and not by glacier erosion. Take the English Lake country as an example. During "the great ice age" that district was covered by a considerable thickness of ice, in some places over 1200 feet, and, doubtless, along that ice, at certain seasons of the year, immense rivers of water would flow, as they do now in Greenland, and, on a smaller scale, in the Alps. Now, these rivers would almost certainly, at one part or other of their course, be engulfed in some of the many yawning crevasses which it is reasonable to suppose would exist in the ice then, as now. Down these crevasses the water would rush impetuously, gaining energy as it fell, until at length it came in contact with the rocks below, on which its denuding effect would be somewhat similar to that of the falling water in Selcoth Burn, only the body of water and the height through which it fell being greater in the former than in the latter case, its action on the underlying rocks would be more severe, and, consequently, a larger rock basin would be produced. An ideal section, illustrative of this suggestion, is given below in Fig. 5.

The greatest depth of Wastwater—the deepest of the English lakes—being about 250 feet, it may seem incredible

that such a body of water could be set in motion along the bottom like the water in Selcoth Burn; but the height through which the super-glacial stream would fall must not be forgotten. It has been shown by the late Mr. J. C. Ward that the thickness of the glacier which passed down Wastdale, over Wastwater, must have been about 1500 feet, measured from the present surface of the lake. The falling water would, therefore, accumulate energy due to a more or less interrupted descent of 1500 feet before coming into collision with the waters of the lake, assuming, of course, what is extremely probable, that then, as now, the basin would be full of water. Surely this accumulated energy would be sufficient to set the 250 feet of standing water in motion, even to the bottom, for the water of Selcoth Burn has in some places only a fall of 2 feet, yet it can set in motion to the bottom, pools that are over 6 feet deep. Again, it may seem equally incredible that a falling river could excavate a basin so much wider than it must have been itself. But in Selcoth Burn we have direct proof that such a thing is possible, for at the falling points a' a'' a''' the stream is very much narrower than it is at b' b'' b''', in one case less than a tenth.

As the glacier shown in the ideal section above moved along its bed, the crevasse down which it is supposed the river fell would move also along with it, so that the point at which the descending waters struck the rocks below would not be stationary, it might be thought, as it is at Selcoth Burn, but would move forward with the glacier. The formation of crevasses at or about a particular point, owing to some change in the configuration of the valley down which the glacier moved, would, however, confine the falling action of the engulphed water to a certain part of the glacier bed, for the latest formed crevasse being farthest up the glacier would always intercept the super-glacial stream or river.

It thus appears that if rock basins have been formed in this way there should be an intimate connection or relation between their position and the form of the valley in which they lie. By way of testing the accuracy of the explanation proposed, let us see if this inference corresponds with fact. For this purpose Fig. 6 has been prepared. It shows most of the English lakes as they are at present, and also those parts of them which have been filled up by alluvium. Taking the original extent of the basins it will be observed that at the head of every one of them the valleys in which they lie send out branches in two or more directions, as shown by the contour lines. Beginning with Wastwater, it will be seen that at the head of the original lake—that is, at the upper end of the alluvial tract which extends northwards from the head of the present lake—the valley divides into two branches, one running towards Scawfell, the other towards Ennerdale. At the head of Buttermere and Crummock—for they may be looked upon as one, and doubtless were one originally—we find the same sort of thing, and so we do, in fact, at the head of most of the other lakes, as well as at the upper end of those alluvial flats—apart from lakes or tarns—which occur here and there in the valley bottoms of the lake district, and which at one time were no doubt so many sheets of water. The head of each lake originally was, therefore, just where, in glacial times, two or more glaciers would unite, and, consequently, where crevasses would be produced continually. Fig. 7 will illustrate this.

It is well known that glaciers, like rivers, move slower at the sides than at the centre. The velocity of the glaciers *A* and *B*, Fig. 7, would therefore be less along *a b* and *c b* than along *a' b'* and *c' b'*. But the side ice *a b* and *c b*, after union at *b*, passes on to *b'*, where its velocity is considerably increased. It is clear, therefore, that between *b* and *b'* a number of crevasses would be constantly forming, so as to

allow the side ice to increase its velocity to equal that of the central ice. These crevasses would swallow up nearly all streams coming from the higher ends of the glaciers *A* and *B*, and the effect of this falling water on the rocks below would be the formation in them of a basin, the head of which would be a little below *b*. Similar crevasses would also be formed where other branch valleys joined the main one, as, for instance, at the side valley branching out opposite the centre of Wastwater, or that between the lakes of Crummock and Buttermere. Such crevasses would swallow up any super-glacial streams they intercepted, and these would help to form the rock basin below as much, perhaps, as the water which fell through the crevasses at the upper end of any basin. In this way I would explain the lower basin of Windermere (Fig. 8). Crevasses being produced at the south end of Claife Heights by the union of the Esthwaite glacier with that coming down from Ambleside, water would rush down through them and form this lower basin, or, at any rate, help to form it, for no doubt several such streams, although of less importance, would pass through the glacier between the Ferry and Lakeside. The lower basin of Ullswater may also be explained in the same way, for on referring to Fig. 2 it will be found that at the head of this basin a large branch valley, coming down from The Nab, enters the main one from Patterdale. At the junction, crevasses would be formed in the glaciers, and those crevasses would swallow up the water thawed from the upper parts of the icefield, which would initiate and continue to deepen the lower rock basin which commences at the point where the two valleys unite. The second basins spoken of by Mr. James Geikie (in his Great Ice Age), as occurring below "narrows," may also be explained in this way, tributary valleys coming in at the head of the second or lower basin.

The existence of islands in lakes presents no difficulty to

this explanation, whilst the fact that the deepest part of the basins is near their upper end, or opposite a secondary valley, might have been predicted. We are also enabled by it to understand the curious holes which are sometimes found in the bottom of lakes, like large pot-holes.

The numerous tarns occupying rock basins may also be explained in this way. As a rule these small sheets of water are found at considerable altitudes, and not far from the water shed. Fig. 9 is a sketch section of Goats Water, on on the side of Coniston Old Man, and it may be fairly taken as typical.

A glacier, after coming down from the higher ground about the Old Man and arriving at *A*, would move off partly down Seathwaite Valley and partly through the comb holding Goats Water. This movement of the glacier in nearly opposite directions would produce crevasses in it on each side of the water shed. Down these crevasses water would almost certainly be carried, and on one side of the water shed form the rock basin holding Goats Water, and on the other side assist in the formation of Seathwaite Tarn, which is a little lower down Seathwaite Valley than where the section is taken.

In some cases tarns occur nearly on the water shed, a position where we would expect to find them if the explanation I am now offering be correct, but certainly not one in which we should look for them if we supposed them to be the result of glacier erosion.

Mr. De Rance said he would rather have not opened the discussion upon the subject of the paper, because it was really an attack upon the opinions of his chief (Prof. Ramsay): at the same time, that was a reason why he should not altogether remain silent. Mr. Kendall's theory was an exceedingly ingenious one, and the author appeared to

have spent a good deal of time and taken much trouble in working it out; still, as far as it affected himself (Mr. De Rance) he entirely disagreed with it. He agreed with Mr. Kendall that there might be certain difficulties in the application of Prof. Ramsay's theory; but the difficulties were still greater in the theory which Mr. Kendall proposed to put in its place. They found, at the present time, in the central position of the Lake district, a distinctly *radiate* arrangement of waterflow,—water was flowing in nearly all directions,—and when they examined a map on which were traced (as on the map of the Ambleside and neighbouring districts, prepared by the late Rev. Clifton Ward and himself,) the lines representing the old ice-flow, there was exactly the same arrangement, and wherever obstruction was offered a rock-basin is found behind it.

One of Mr. Kendall's difficulties lay in the fact that in certain cases which he presented, the diagrams were not drawn to true scale. When they came to draw the rock basins of the Lake district to true scale, they saw at once—(taking, for instance, the case of Ullswater,)—that so far from presenting a deep gorge on a six inch scale, the depth was comparatively inappreciable. Prof. Ramsay never professed to say that the valley in which Windermere or any of the lakes was situated was formed by ice: he merely said that that portion of the valley which lay beneath the water level,—beneath the level at which the water flowed away from the lake at the present time was so formed. All they had to account for was not the depth of the Windermere valley,—2000 to 3000 feet,—but the 234 feet below the water level. At the place where two glaciers met, according to Mr. Kendall, the central ice would be very much crevassed, and a great pot-hole would be formed. If that was so, they would expect to find that pot-hole at the top of the lake. But it was not there; for the deepest part of Lake Windermere was neither at the top nor at the middle of the lake, but at the side, just

opposite Wray Castle. When they examined such rock-basins as Rydal and Grasmere lakes they found that the water had cut a passage at the foot of each by which it escaped, and that the *rôches montonnées* at the foot of the lakes were all scratched and scored, pointing to the flow of ice being arrested, and a passage scooped out in the manner suggested by Prof. Ramsay. The Professor seemed to him to have an excellent argument in the fact that if you examine the map of any glaciated country in the world there you always find lake basins. Mr. Kendall might of course say that there was ice in which were formed crevasses, and that through these water flowed, forming hollows.

Mr. Kendall referred to Greenland. The great difficulty as to Greenland was that, according to the information we possess, there are no hills and valleys under the ice at all. If they drew a section through Greenland they had a certain rocky territory on the east and a certain rocky territory on the west of the country, and between the two was a great dome of ice; but as far as anyone knew—and Prof. Nordenskjold himself thought so—there was a great flat at, or it might possibly be below the sea level, beneath that dome of ice. Water falling through crevasses in the interior escaped from the base of the ice, which filled up the gorges betwixt the rocky islets and the edges at the circumference; in fact you may compare Greenland to two gigantic saucers, one at the bottom representing rock; the other at the top representing ice. The water which escapes at the edges is full of detritus, and makes the great shoals that form at the entrance to all the bays of Western Greenland. It is not known that, in Greenland, rivers are running under the ice and making valleys, and any theory to account for the origin of rock-basins, must not merely explain the formation of the small lakes of Britain, but the far larger lakes of Italy and Switzerland.

Mr. AITKEN said that Mr. De Rance had had so great

experience in the Lake district, and he spoke with such authority, that little needed to be added to what he had said. But one idea struck him (Mr. Aitken) during the reading of the paper which it might not be out of place to mention, namely, that if rock basins began to be formed as pot-holes under where crevasses were generally formed, these crevasses would be filled at the bottom with a very considerable depth of water—the depth to which the pot-hole had been sunk. It seemed to him that that would prevent any erosive action of the water which subsequently might fall at the same place. Water in sufficient volume would not exist, and even though it did there would be an absence from it of that material which did the filing away of rocks and cutting of river courses under other circumstances; consequently it appeared to him, that after a small pot-hole had been formed and had become filled with water, the other water falling in could not have the effect which Mr. Kendall ascribed to it. There was another difficulty: if the crevasses were formed by two streams of ice, as described, the pot-hole would be confined to the particular place of meeting. But in the case of Windermere—not to speak of the larger lakes in Switzerland—there would be required a continual motion of those crevasses to allow the erosive action to take place over an extended area. He could not understand how, on that principle, Windermere could have been formed—a lake 13 miles long and of considerable depth for a great portion of the distance—so that it would therefore appear that Mr. Kendall's theory was no improvement on that of Prof. Ramsay—although, as Mr. De Rance had stated, every geologist must admit that the question was beset with difficulties. On the whole, in his (Mr. Aitken's) judgment, Prof. Ramsay's view was preferable to that of Mr. Kendall.

Mr. PLANT said he had listened to Mr. Kendall's paper with attention, because, as had been stated, the subject was surrounded with difficulties. Whenever he visited the

Lake Districts, he endeavoured to form for himself an ideal of what these must have been at the time when the glaciers were scouring out the basins of the lakes—especially those of Wales, which were less extensive than the English lakes—but he had never been able to be quite satisfied with Prof. Ramsay's theory, or even his illustrations, as quite sufficient to account for the origin of these lakes. He had listened to Mr. Kendall's remarks with considerable interest, but he was not inclined to think that that gentleman had bridged over the difficulty, or that he had added anything to what was previously known. His theory of waterfalls within the crevasses seemed certainly a novel one; it was well known that water found its way down crevasses, and it must have the effect of washing out a great deal of the detritus which had accumulated at the bottom of the glaciers; but he (Mr. Plant) could not conceive that the water would have force sufficient to wear away and continue wearing away until it formed an elongated lake basin in the rocky floor. The theoretical explanation of what might be in the interior of Greenland hardly applied in this case; they wanted facts in geology wherever they could get them; and if Mr. Kendall could have given them an illustration where the action he described had undoubtedly taken place, he should have been inclined to regard it with considerably greater satisfaction than he did.

The CHAIRMAN (Mr. Dickinson) said he was glad to see one gentleman, at least, who would come and give the Society a paper based upon sound reasoning, showing that the glacial theory was not to be accepted without some debate; and he was also pleased to find that both Mr. Aitken and Mr. Plant recognised the difficulties with which the glacial theory was surrounded. The arguments put forward by Mr. De Rance were certainly very able and very strong, and, he thought, perhaps, such as Prof. Ramsay himself might have brought

forward in support of the theory; but to his (the Chairman's) mind, the glacial theory was based simply upon hypothesis—nothing more—and that there were no facts, nothing but a few coincidences in its support. He would not say that Mr. Kendall's theory was free from similar hypotheses; first, the depth of Windermere, alluded to by Mr. De Rance—that was sufficient to set aside the possibility of a running stream. Where was it to run to, when it was 100 feet below the level of the sea? That, to his mind, was an insuperable difficulty. Then, again, the radiate arrangement of the lake basins, spoken of by Mr. De Rance—that equally upset the likelihood of glaciers radiating out from one common centre on the mountain top. The subject was, indeed, beset with difficulties. Who could tell but that a far too limited view was being taken of the cause and effect of the removal of the upper coating of the earth? They found thicknesses of many miles removed in places. Where has it gone to? He did not think they had before them yet any recognised geological theory which accounted for it. Many years ago, as some gentlemen might recollect, he brought before the Society a paper showing the possibility of the whole planetary system having been at one time united, and that the so-called "denudation" was where the original structure became divided, as each planet left and took its particular orbit. The idea was laughed at at the time, but it might be none the less true for all that. When he first advanced that idea it was not known that the earth and the planets were composed of the same materials. Since then that wonderful discovery of the spectrum analysis had shown that they do consist of the same materials, and until he found some better theory than either the glacial theory or that which Mr. Kendall had put forward, he should adhere to the view which he had held now for a quarter of a century.

Mr. KENDALL briefly replied to the several speakers.

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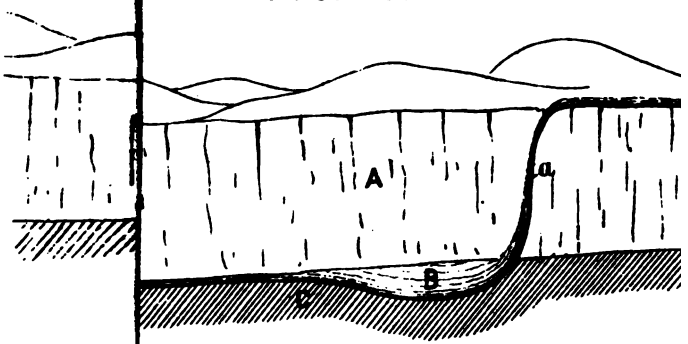
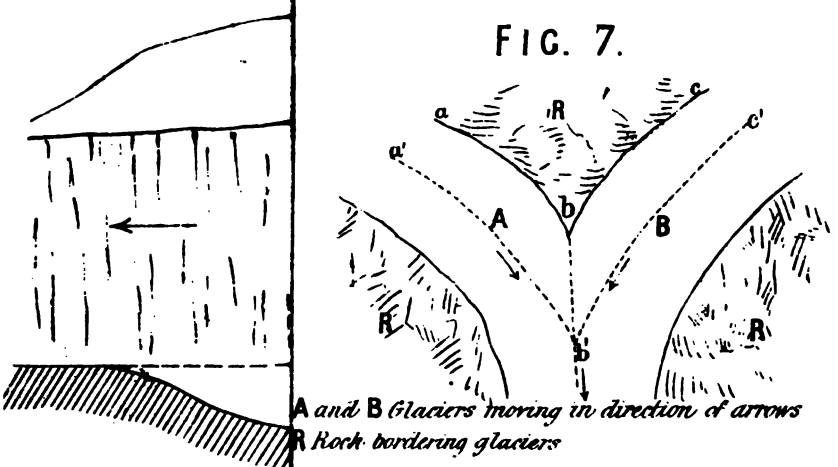
FIG. 5.



ier moving in direction of arrow. a Crevasse
basin full of water
(glacier bed)
rglacial Stream S' Sub glacial stream

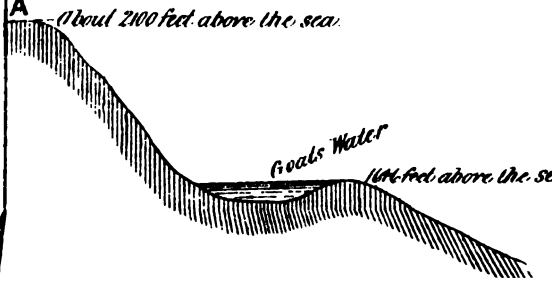
FIG. 7.

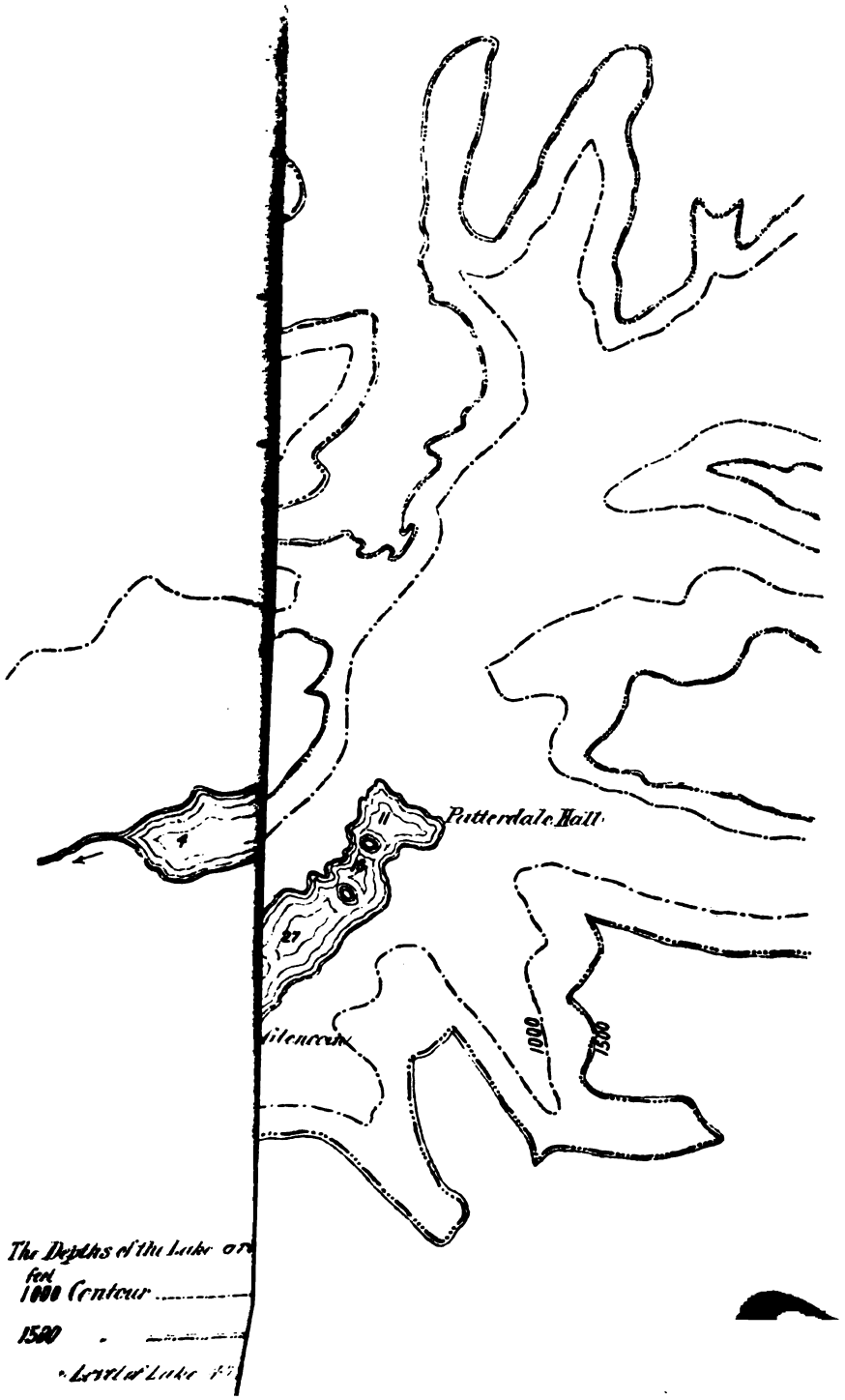


A and B Glaciers moving in direction of arrows
R Rock bordering glaciers

FIG. 9.

ht of Old Man 2633 feet above the sea
A about 2100 feet above the sea

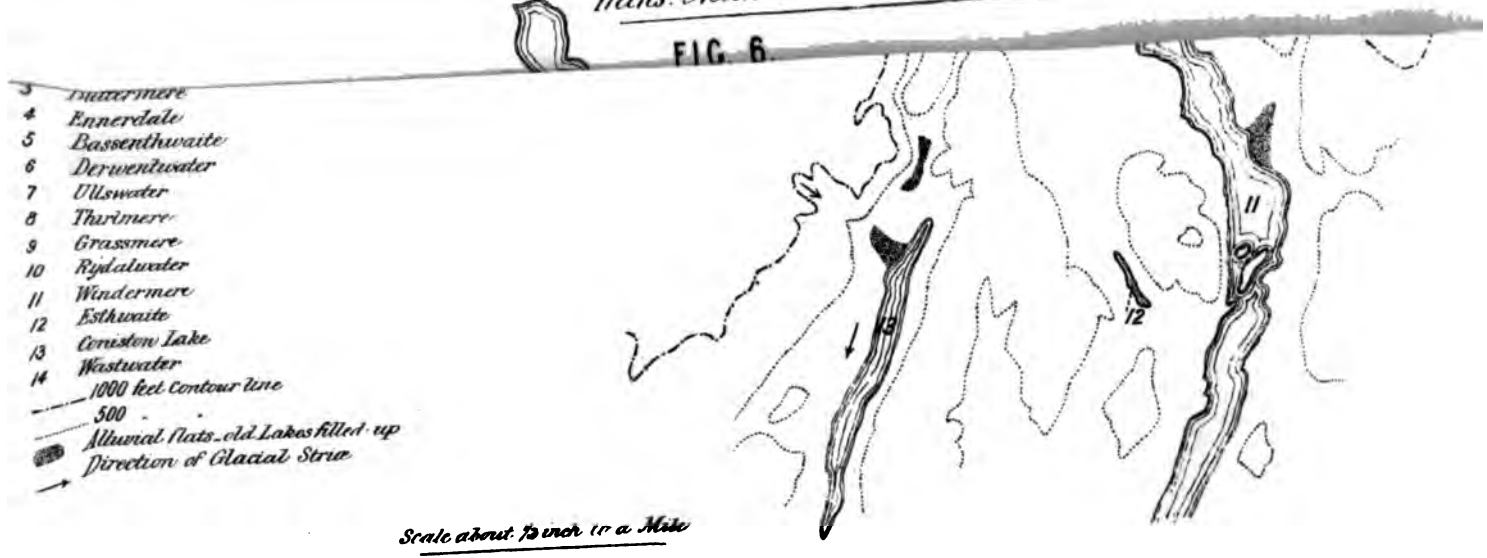


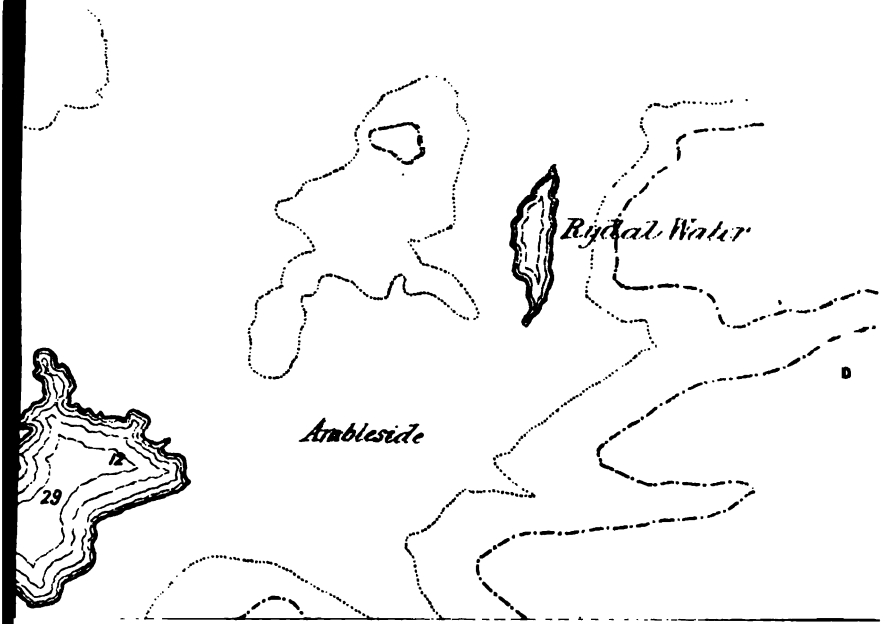

Patterdale Hall
1000
1500
The Depths of the Lake are
feet
1000 Contour
1500

TO ILLUSTRATE MR. KENDALL'S PAPER ON ROCK BASINS,

Trans. Man. Geo. Soc. Part XVII. Vol XV.

FIG. 6.




Rydal Water
Ambleside
12
29

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVIII. VOL. XV. SESSION 1879-80.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 29th day of June, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKEN, Esq., Vice-President,
in the Chair.

Mr. William Crompton, Colliery Proprietor, Ince, near Wigan, was elected an ordinary member.

THE SINKING AT BAMFURLONG COLLIERY.

The CHAIRMAN announced that the paper read at a former meeting by Mr. Walter Topping, on "Sinking at Bamfurlong Colliery," was now open for discussion.

Mr. PERRIN said that the chief point of interest in the sinking in question was the way in which the quicksands were got through. They presented the greatest engineering difficulties, and in this case he considered they had been most successfully grappled with.

Mr. TOPPING said the lining of the Bamfurlong pits was effected by means of wooden curbs: they had, since his paper was read, had to re-line them with an iron casing, at a cost of £400 to £500.

ON THE "SPARK TUBE," OR INFLAMMABLE GAS INDICATOR.

By Dr. Angus Smith.

In introducing this instrument to the notice of the members, Dr. Angus Smith said: I have not thought of writing a separate paper upon this subject, because, in my last annual report, under the Alkalies Act, where I generally speak about gases of various kinds, I gave an account of this tube; and I at this time have only written a very small addition. I also gave a drawing of the tube: that, however, can be seen for itself here. (Dr. Smith exhibited the tube to the meeting.) The idea is this: I dare say all the members know the old compression syringe, used to prove that when gases are highly and rapidly compressed they give out heat. For this purpose there is simply a cylinder, which may be either of glass or of brass, with a piston in it, pretty tight. At the bottom of the cylinder there is usually placed a piece of tinder, or some such thing, and by a simple blow with the hand, compressing the gases, heat is generated in sufficient quantity to ignite the tinder. It occurred to me, a long time ago, that this might be used for igniting the gases in mines; but it was only very lately that I got an instrument made for the purpose. We tried many tubes—of glass, for example, the ordinary compression tube which is sold for the purpose. I may say there are two compression tubes sold, one of glass, the other of brass. We tried the brass one, with the gases of mines, and found that it was bulged out with a violent explosion, to a very great extent. We tried then the glass ones, which are made of very thick glass, and we found that they were broken very readily. It was found necessary, therefore, to use a somewhat different apparatus, so we simply made a cylinder of very thick brass, which would prevent anything

of the kind. But, as it was necessary to *see* the explosion, glass could not be altogether dispensed with. By enlarging the base, room was made for a small cylinder of glass, which was somewhat of the same diameter, but a little larger, than the brass cylinder, so that the end of the piston might go down. But, in order to cause the cylinder to escape the glass more readily, it was made a little narrower at the extreme end. By using, then, simply the hand, a blow was given which compressed the gases and raised them to such a point of heat that, if they were explosive, they would take fire, and the explosion would be seen through this little window. That is really the whole of the apparatus. We may imagine, then, a miner testing the air for gas: he would leave his lamp in a safe place and go forward, making trials, as often as might be necessary, with this apparatus; on placing his lamp upon the floor in any working place, he might test the air about the roof, feeling safe that, if gas happened to be present, there could be no explosion from the use of the tube, because the spark or flame produced is very small and entirely confined within the tube. The tube, however, required to be made excessively tight, and, in effecting this, we tried oil as a lubricant; but this would not do, as the oil got ignited, and there was always an explosion with it. It was, therefore, necessary to use some other substance, and we have tried, hitherto, soap and water, which seems to do very well. We found, by this method, that about five per cent. of gas, if mixed with air, could be detected. This was not a very delicate test, so we proposed to increase the delicacy by adding a little platinum black. This platinum black is put either to the end of the piston-rod or to the bottom of the cylinder—a very minute quantity being sufficient, say a piece the size of a pin head. This doubles the power of the apparatus, and we get explosions when there is two to two and a half per cent.—always when two and a half—of gas present. I think we have sometimes

detected two per cent., but I do not think we have gone further in delicacy than that. I place the instrument, such as it is, before you. When the explosion does take place, the air of the spot to be tried must be driven in again before another experiment can be made. In order to do that, it was, at first, thought necessary to put in a rod of glass, by which means the air that had exploded was driven out: then, upon withdrawing the glass rod, the air of the place rushed in. My first idea was to put in a stop-cock, but I was afraid it might cause a complication, as the least opening spoils the apparatus. However, I have one here with a stop-cock at the bottom: the advantage of that is that we can draw in a fresh supply of air, and conduct a fresh experiment in that way. But this apparatus is not at present in a workable condition—it has just come from the workman, and is not quite tight. I suppose we shall be able to have it made ultimately so that the two metal surfaces will work upon each other with sufficient closeness to prevent the necessity of any substance whatever being used for lubrication. In the absence of that we must return to the soap and water; but I think it is within the power of mechanism to make it so.*

Several experiments with ordinary coal-gas were conducted in presence of the members, with success.

Mr. Teale asked whether it would be possible to tell the per centage of gas in a mine by means of the spark tube.

Dr. Angus Smith said he was afraid this could not be done. He, however, thought that a man who had had a good deal of experience might tell pretty nearly by the flash whether there was little or much gas, but it would never be an exact measure of quantity.

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* Note.—The piston did not reach to the bottom of the cylinder; if it reaches too near and great force is employed light may be observed, as Mr. Dancer has shown, and as the well-known heat would indicate.

Mr. DICKINSON said that both Dr. Angus Smith's instrument and that of Professor Forbes, exhibited at a previous meeting, seemed to be opening out a new test in mining, which—particularly in those mines where gunpowder was used, and where there was a large per centage of gas—was likely to produce excellent results.

The CHAIRMAN said that the invention seemed to him to present one difficulty, namely, that a light would be needed within the mine by the person using the tube; and there would still be the risk which would attend the taking of a lamp into places where gas might be lurking.

Dr. ANGUS SMITH said he had thought of that difficulty, but, as he before mentioned, he supposed in the first place that there were parts of the mine which were free from gas, and the miner could go into these with his lamp; taking his lamp as far as might be convenient, he would leave it and proceed to make trials with the tube in different places. The great danger from gas was, he believed, when it lodged in quantities in the roof: in such cases the miner would place his lamp on the floor, and, filling the tube with air from the roof, would make the requisite tests in perfect safety. He (Dr. Smith) did not, of course, bring the instrument forward as a complete and finished invention, which was to prevent all explosions for ever in coal mines; he brought it simply as an idea which he thought might be useful in the prevention of explosions. He did not say that it was the best idea, but it was a novel idea, and if anyone thought it was likely to be useful, it was at his service, and he would be happy to assist in further developing it. The test was not so delicate as Professor Forbes', because his instrument indicated one per cent. of gas; the spark tube, he did not think, had ever gone finer than two per cent., but it might, in some cases be more convenient, and might be used by a rougher hand, than Professor Forbes'.

FURTHER NOTES OF TRIASSIC BORINGS NEAR WARRINGTON.

By C. E. DeRance, F.G.S., Assoc.Inst.C.E., of H. M. Geological Survey.

In a paper I laid before the Society in February of last year, I stated that I considered the hard compact sandstone, met with in Bootle boring at a depth of 1228 feet from the surface, belonged to the Lower Mottled sandstone. I also called attention to the rounded character of the fragments of the soft sandstones lying between the base of the Pebble Beds, which occurred at 1039 feet, and the top of the hard bed just described, and I further attempted to show that the rounded, or "millet seed grain," is present in the hard rock beneath, which is simply the softer sandstone cemented together by lime. This boring having failed to penetrate the hard rock, though carried to a total depth of 1334 feet, left a certain amount of doubt as to the correctness of my identification, and I have since learned that several authorities refer the rock in question to the Permian, or to the Coal Measures. I am, therefore, anxious to lay before the Society additional information, which, in my opinion, satisfactorily proves the correctness of my conclusions.

In February, 1879, I was unacquainted with any rock resembling the hard compact sandstone of Bootle, in May of the same year I was much interested to recognise it, in a series of samples of cores shown me by Mr. Timmins, of

Runcorn, the contractor for the well-borings and other works now being put down at Winwick, near Warrington, and on going through the series of specimens occuring beneath the hard band, I had the satisfaction of finding that the hard band at Winwick is underlaid as well as overlaid by soft running sand, with a millet seed grain, the whole series most certainly belonging to the Lower Mottled sandstone. Beneath them are 49 feet of indurated mottled grey and dark marls, and calcareous bands overlying good limestone which appears to precisely correspond with the Upper Coal Measure limestones near Manchester, and the limestone proved in the Clayton Vale boring described in the Transactions of the Society, by Mr. Atherton, the cores from which I had the opportunity of examining through the courtesy of Mr. Vivian, of the North of England Rock Boring Company. These coal measure deposits occuring at a depth of only 340 feet or 113 yards from the surface, cannot but be regarded as a discovery of the highest commercial importance, as well as of scientific interest, for looking to the westerly attenuation of thickness of the coal measures of South Lancashire, to which I have already drawn the attention of the Society, there can be little doubt, but that the Manchester coal-field will occur at a less depth beneath the limestone than at Manchester, in which case a valuable and workable coal-field may be under the London and North Western Railway at Parkside, where a boring has also recently been carried out, and where the coal measures have probably been reached at even a still smaller depth, but the particulars of which I have not as yet been able to find time to procure, it necessitating a visit to North-Western works at Crewe where the cores are preserved.

The following is the journal of the Winwick boring:—

Ft.	in.		Ft.	in.	
		Moss	2	0	Drift.
30	0	Fine white sand	28	0	
127	5	Fine grain sandstone	97	5	New red sandstone 3′ 10″
172	6	Coarse compact sandstone, with millet-seed grain and red marl bed	45	1	
182	0	Shaly marl	9	6	
201	0	Fine grained (L. M.) sandstone	19	0	
212	0	Hard sandstone	10	0	
		Sandy marl	2	0	
214	0	Marl			
226	0	Calcareus sandstone	12	0	
252	6	Marl	26	6	
270	6	Large grained sandstone	18	0	
276	6	Marl	6	0	
298	6	Soft white sand	22	0	
329	6	Soft brown sand	31	0	
340	6	Red sandstone	11	0	
351	6	Mottled grey marl	11	0	33′ 6″ Upper coal measures.
360	0	Dark mottled marl	8	6	
365	0	Hard brown sandstone	5	0	
369	0	Brown marl	4	0	
373	0	Variegated marl	4	0	
385	0	Marl	12	0	
396	0	Limestone	11	0	37 feet of Lime-stone.
399	0	Marl	3	0	
408	0	Limestone	9	0	
412	0	Compact limestone	4	0	

The dip of the Pebble-Beds in the neighbourhood is to the south-east, and south at low angles, in Nos. 1 and 2 shafts, the strata consist of soft red moulding sand without pebbles, very easily worked. No. 3 Shaft exhibits characteristic Pebble-Beds, the current-planes being covered with dark mica, the rock is hard and contains pebbles. No. 4 shaft, near the Spa Well, also is undoubted Pebble-Beds, though moderately hard, and contains many pebbles.

A drift, or level is being driven to this shaft from the pumping station 1200 yards distant, which will doubtless throw much light on the structure of these sandstones, a powerful spring of water was met with in No. 4 shaft at a depth of about 90 feet from the surface.

The level of the Parkside Wells of the North-Western Railway will be about 110 feet above O.D., that of Winwick pumping station 125 feet, that of the Spa Well about 96 feet, that of the Dallam Lane Forge Well about 43 feet. Between Golborne and Parkside, true Pebble-Beds occur dipping east, from Parkside to Spa Well, they continue and gradually change their direction of dip to south-east, as is well seen at Middleton Hall quarry, near Spa Well. Had not this change of strike taken place the base of the Pebble-Beds would have cropped out north of Winwick, instead of which they occupy a considerable tract around Golborne, and the thickness of triassic strata at Parkside would have been much less than at Winwick 1¼ miles to the south, the strike of the rocks nearly coinciding in direction with a line drawn between the two wells.

Between the Winwick pumping station, and Dallam Lane Forge 2⅓ miles distant this is not the case, the Pebble-Beds at Hulme Delf, south of Winwick, dip south at or directly on the Dallam works, the dip varies in different quarries from 4° to 8°, taking it at 4°, and the base of the trias at Winwick at 215 feet below O.D., and assuming the surface of the Coal-Measure beneath the trias to correspond to the amount of dip, the base of the trias would be carried down 1000 feet at Dallam Lane Forge, or 1215 feet below O.D., and 1258 feet below the surface.

The boring of which I gave details* actually penetrated of this thickness 880 feet, the bottom beds met with being 70 feet of soft Lower Mottled sandstone, with the millet

* Trans. Man. Geol. Soc. 1879.

seed grain, occurring immediately beneath pebble bearing Pebble-Beds, so that these soft beds evidently belong to the uppermost portion of the Lower Mottled series, these we have seen at Winwick reach a thickness of more than 200 feet, and at Bootle boring of more than 300 feet; in the latter case, without their base being reached, so that they may possibly be 350 feet thick under Warrington, in which case their base will be 1230 feet beneath Dallam Lane Forge which closely agrees with the calculation of the probable position of the base of the Trias, based upon the observed dips at Winwick. There is, therefore, strong evidence to believe that the Coal-Measures under-lie Warrington at a depth of 400 yards, but at what angle and in what direction they dip there is no evidence to show.

The higher coals of the Wigan coal-field, the Ince mines, are striking nearly south, between Town Green, Ashton, and Edge Green, Golborne, and, did no fault intervene, their southern prolongation would pass through Newton Bridge and Great Sankey, but it is repeatedly thrown back westwards by faults, with westerly downthrows, so that the coal measures between Winwick and Sutton are higher measures lying above the Lyons Delf, of St. Helens, and probably in great part, belong to the Upper (or Manchester) coal-field. In the centre of this tract a colliery has been sunk on Bold Moss, east of St. Helens Junction, for opportunities to view which and for copies of the section passed through, I have to thank Mr. Harbottle, the managing director, several coal seams have been passed through, and these have been supposed to be identical with the upper seams of the St. Helens field, but after having the section drawn to scale and compared with the neighbouring collieries, I am inclined to think that these coals are on a higher horizon and probably belong to the upper coal measures. Progressing westwards, the first fault with an easterly downthrow is that passing

through Whiston, which with that passing Sutton Heath, throws in the remarkable trough of New Red sandstone, extending from Rainhill to Eccleston Hill, which I have lately had the opportunity of examining in great detail, and it will be noted that it is in this triangle that the small tract of Upper Coal-Measure limestone is brought by faults to the surface at Huyton, long since described by Mr. Binney and Prof. Hull; here we have the normal S. W. and N. E. strike of this area, and should this continue eastwards, and the limestones proved as Winwick range in this direction with a south-easterly dip, the measures underlying the trias of Warrington, must be very considerably above the horizon of the limestones and higher to the series than any coal-measures cropping to the surface in Lancashire. But should the limestones of Winwick belong to the same horizon as those of the Manchester coal-field, it is in the highest degree probable that another 600 feet, and possibly much less, would reach the Openshaw coal or its equivalent.

Microscopic Structure.—Through the kindness of Messrs. Mather & Platt, of Salford Iron Works, the contractors for the Liverpool Corporation boring at Bootle, I have obtained a series of samples of parts of the cores brought up from different depths, some of which I have submitted to the experienced microscopist, Mr. John Arthur Phillips, who has compared them with each other, and other sandstone sections, from whose examination it appears the hard rock is composed of similar rounded grains to the soft rock, and from the character of the surface of those grains, there is a strong reason to believe they were originally an ancient blown sand. A large number of other interesting phenomena resulted from Mr. Phillips' examination, as to the origin and composition of the grains, the presence of crystals of subsequent growth on their surface, these and other matters foreign to this paper, will be embodied in Mr.

Phillips' investigations on the sedimentary rocks, on which he is now engaged.

Those who have studied the method of occurrence of blown sand on the Lancashire coast know that of necessity pebbles are rare, the sand is largely current-bedded by the action of the wind; that rain-water charged with carbonic acid gas percolating through sand-hills dissolves out shells of mollusca, and that these seldom occur; that the low flat tract between sand-hills are subject to floods, and inhabited by toads.

Studying the Triassic rocks of Lancashire in reference to these characteristics, we have, in ascending order, the *Lower Mottled Sandstone*, composed of rounded grains, resembling those of modern blown sands, and no traces of life. *The Pebble Beds*, sandstone with pebble banks or beach following lines of current bedding and old water margins—pointing to the movement of water or currents causing denudation, and the arrest of the velocity of the movements of these currents, causing deposition. The Pebble-Beds contain inconstant shale beds pointing to local currents, tranquil deposition, which the pressure of pseudo-morphous crystals of salt prove, took place in isolated lagoons. The *Upper Mottled Sandstone*, pebbles are exceedingly rare, shale beds uncommon, and beds of millet seed grain often occur, especially towards the upper part, which nearer the base are lines of erosion, the rock eroded being invariably sustained by coarse-grained rock, resembling in character that of the Pebble Beds, and that formed at a later period at the base of the Keuper series. The *Lower Keuper* building stones are all hard, compact, and angular-grained; they are associated with shale-bands, plant and labyrinthodont remains; at the close of this episode, the sources of coarse material appear to have been cut off, and the water depositing fine sands—alternating with marls—was tranquil, undisturbed, and unmoved by currents.

Water-Supply.—The soft, millet-seed grained, moulding sands of Town Green, near Ormskirk, belong to the Upper Mottled sandstone, but occupy a lower horizon in it than the more compact sandstones faulted in west of the railroad, in which the principal well-borings of the Southport Water Works have been carried. But the soft beds afford the water-bearing horizon in the wells of the Widnes Local Board, at Stockwells and Netherlee.

At Dallam Lane forge boring, as stated in my previous communication on the subject, distinct traces of a fault occur at 753 feet; and at 384 feet, Mr. Beck found the beds turned on end, due, in his opinion, to a second fault. That one fault occurs, ranging up from the south side of the river, is undoubted, and I was inclined, with Mr. Strahan, to attribute the brine spring met with to the action of this fault, leading the brine from the salt district, in the Keuper marls, to the south. But during the past year, after careful study of the action of faults on the passage of water, I have given up the position as untenable.

Where two porous, permeable rocks, are thrown against each other by a fault, the dislocation offers little resistance to the passage of water through the fault, and affords no facilities for its passage along its length—either between its walls or along the face of the upcast slope.

Where two impermeable beds of shale, or clay, are thrown against each other, the fissure of the fault is narrow, that it seldom includes foreign materials, and water can neither pass through, or along it.

Where permeable formations are thrown against impermeable rocks by faults, the district is divided into water-tight compartments, water flowing down the dip planes of the strata, ponding up on the dip side, travels along the face of the fault and rises until it escapes, where the porous rock crops to the surface and is cut off by the fault, the course of which is marked by a line of springs.

In the case of the fault traversing Warrington from the south, the fissure of the fault in the salt-bearing marls would be close, and unavailable as a duct, and supposing even brine-laden water to have sunk into the sandstone beneath, these being porous would absorb it equally in all directions, and would be incapable of conveying it in the fissure of the fault to their outcrop to the north under Warrington.

Looking to the probable proximity of the coal measures to the surface, and that salt-springs occur in many coal-fields, and, indeed, in the Wigan coal-field, near Worthington, I am inclined to believe the brine-springs of Dallam Lane to be of coal measure origin.

Mr. DICKINSON said that in the paper which he had read Mr. DeRance spoke of the rocks bored through, both at Winwick and at the Dallam Forge, as being mottled sandstone, with the pebble beds below. About a year ago a paper upon that subject was read by Professor Hull in which the rocks in question were attributed to another and quite a different formation. Professor Hull had laid down the geology of those rocks upon the Geological maps, and the object of his paper, read before that Society was to disprove his own previous work. So far as he (Mr. Dickinson) was aware all those members who took an interest in the matter considered that the Geological map was right and that the Professor's more recent conclusions were wrong. He would like Mr. DeRance to say whether he considered the map to be right, or otherwise?

Mr. DERANCE: The map, I think, is correct.

Mr. DICKINSON said he quite coincided with Mr. De Rance, and that Professor Hull went out of his way to prove his own work to be wrong. He (Mr. Dickinson) had never had an opportunity of seeing the limestones at

Winwick, which were sunk to for the water works; but he knew Permian limestone had been met with and worked at Patricroft; also at Astley and West Leigh; and had been sunk through again in the new pit at West Leigh. It was generally supposed that the limestone met with at Winwick was Permian too. If Mr. DeRance, from observation, was able to say that it was carboniferous and not Permian it would really be a most important distinction, which would require to be understood and recognised.

Mr. DeRance said he believed there were fossils in it,* but he had not seen them. He might say, with regard to the faults, that he believed the reason why Professor Hull came to the conclusion he did was the very extraordinary quantity of salt found in the boring at Dallam Lane, and the great similarity of the top beds there to the upper beds of the Keuper. Mr. DeRance read the following letter from Mr. Beck, of the Dallam Lane Works:—

"Whilst we were boring at Dallam Lane Forge, the water stood in the bore from 31ft. 6in. to 35ft. 6in. from the surface, being slightly affected, I presume, by the neighbouring wells, which were kept down to a level of about 60 feet during the week. The 31-6 was registered on a Tuesday, and the 35-6 on a Friday. The highest amount of chlorides was from a sample brought up from the bottom of the bore, the *average* of the bore at the time being about 1900 grains to 2200 at the full depth. I did not get a sample from the bottom. The average samples were taken after some hours pumping with the bore closed and the pump drawing against a 15 to 20 inch vacuum."

From all that he (Mr. DeRance) had seen there was no reason to suppose trough faults throw in higher beds at Dallam. A fault, however, traversed (North and South)

* Since writing the above, I have been informed that *Spirorbis Carbonarius* has been detected by Mr. Siddal, of Chester, in a microscopic section of the Winwick limestone, which substantiates my views.—C. E. R.

through Warrington, throwing certain measures against similar measures—and it was met with not only in the Dallam Lane sinking, but also in another boring belonging to the same Company at the Warrington Wire Iron Works,* where a well was sunk which was also brackish; and it had been suggested that it was by means of this fault, which was known to occur at the surface south of the river, and to traverse the red marl district, acting as a duct, that the salt was drawn from the salt districts of Cheshire. He did not, however, see how that view could possibly be sustained.

End of Vol. XV.

* I have to thank Mr. Beck, of Dallam Lane Forge, for much information; also Mr. Timmins, of Runcorn, and his son, Mr. A. Timmins, Stud.Inst.C.E., for many facilities and for assistance.—C. E. R.

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